NEW ZEALAND

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NZS 6806 (2010) (English): Acoustics - Road-traffic noise - New and altered roads [By Authority of New Zealand National War Memorial Park (Pukeahu) Empowering Act 2012 (Public Act 2012 No 76)]

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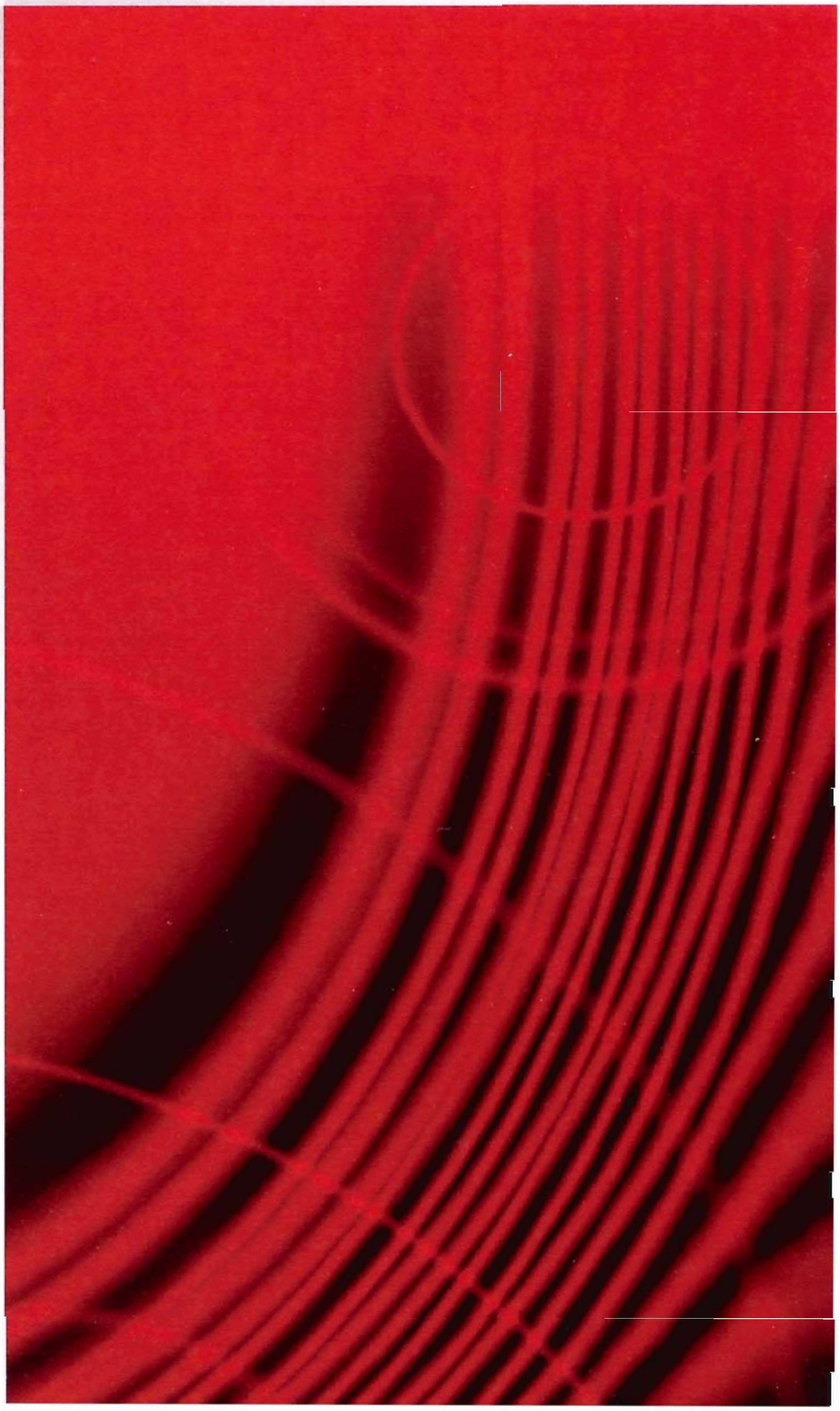
New Zealand Standard

Acoustics – Road-traffic noise – New and altered roads

NZS 6806:2010



COMMITTEE REPRESENTATION

This Standard was prepared under the supervision of the P 6806 Committee, the Standards Council established under the Standards Act 1988.

The committee consisted of representatives of the following nominating organisations:

Department of Building and Housing
INGENIUM
Local Government New Zealand
Ministry of Health
Ministry of Transport
New Zealand Acoustical Society
New Zealand Institute of Environmental Health Inc.
New Zealand Transport Agency
Road Controlling Authorities New Zealand Inc.
Roading New Zealand

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Standards New Zealand gratefully acknowledges the contribution of time and expertise from all those involved in developing this Standard.

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New Zealand Standard

Acoustics – Road-traffic noise – New and altered roads

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NZS 6802:2008	Acoustics – Environmental noise
NZS 6803:1999	Acoustics – Construction noise

JOINT AUSTRALIAN/NEW ZEALAND STANDARD

AS/NZ 2107:2000	Acoustics – Recommended design sound levels and reverberation times for building interiors

ISO STANDARDS

ISO 140: - - - -	Acoustics – Measurement of sound insulation in buildings and of building elements
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LATEST REVISIONS

The users of this Standard should ensure that their copies of the above-mentioned New Zealand Standards are the latest revisions. Amendments to referenced New Zealand and Joint Australian/New Zealand Standards can be found on http://www.standards.co.nz.

The Standards Act 1988 states that a reference made to a Standard in any Act, regulation, or bylaw refers to the latest edition of that Standard. However section 23 of the Act also makes an exception where the context otherwise requires. Under the Resource Management Act 1991:

(a) Where a New Zealand Standard is incorporated by reference into a national environmental standard or national policy statement, such as the New Zealand Coastal Policy Statement, and that Standard is amended or replaced, the amended or replacement Standard has legal effect as part of the national environmental standard, or policy statement only if the Minister for the Environment publishes a notice in the New Zealand Gazette giving it legal effect; and

(b) Where a New Zealand Standard is incorporated into an operative or proposed regional or district plan by reference and that Standard is amended or replaced, the amended or replacement Standard only has legal effect as part of the plan if a variation or change to that plan is made which states that the amended or replacement Standard has legal effect.

Further, the Environment Court has held that where a New Zealand Standard has been cited in a condition of resource consent, the relevant version of that Standard, and the relevant version of any other Standards referred to in that Standard, are the versions current at the time the consent was granted.

Commentary

If this were not the case, Resource Management Act documents could be altered, not by the appropriate planning authority and processes provided by the Resource Management Act, but by the Standards Council and its processes under the Standards Act.

REVIEW OF STANDARDS

Suggestions for improvement of this Standard will be welcomed. They should be sent to the Chief Executive, Standards New Zealand, Private Bag 2439, Wellington 6140.

FOREWORD

This Standard covers the management of noise for new or altered roads. It is intended to be:

(a) A relevant matter to take into account when exercising functions and powers under the Resource Management Act, including when making decisions or recommendations in relation to resource consents, outline plans, and designations; and

(b) A Standard which could be incorporated by reference into national environmental standards, national policy statements such as the New Zealand Coastal Policy Statement, and plans prepared under the Resource Management Act.

This Standard has been developed to fulfil an identified need for formal guidance on methods and criteria for the measurement, prediction, assessment, and mitigation of noise from new or altered roads.

This Standard includes recommended noise criteria to be applied to noise from new or altered roads received at the assessment positions of protected premises and facilities.

The Standard provides guidance on the methods and criteria for the measurement, assessment, prediction, and mitigation of road-traffic noise from new or altered roads, including in appropriate circumstances noise received indoors.

The $L_{Aeq(24h)}$ unit is established as the preferred metric for the assessment of road-traffic noise in New Zealand. L_{Amax} criteria are not included in this Standard because road controlling authorities do not have direct control over individual vehicle noise.

This Standard does not cover noise from:

(a) Individual (noisy) vehicles – other laws and regulations control these vehicles; and

(b) Existing roads that are not being altered.

OUTCOME STATEMENT

This Standard will assist road controlling authorities, developers, and consent authorities to manage the effects of road-traffic noise from new and altered roads through the provision of consistent procedures and requirements for the measurement, prediction, assessment, and mitigation of such noise.

This will help to achieve quicker and consistent decision-making nationally.

NEW ZEALAND STANDARD

Acoustics – Road-traffic noise – New and altered roads

1 SCOPE

1.1 GENERAL

1.1.1 This Standard recommends noise criteria to be applied to road-traffic noise from new or altered roads received at the assessment position(s) of protected premises and facilities (PPFs). This Standard does not apply to existing roads.

The noise criteria are intended to address the adverse effects of road-traffic noise on people. Land-use planning is the preferred method of avoiding these effects. Where this is impracticable the Standard sets out procedures and methods for the prediction, measurement and assessment, and guidelines for mitigation of road-traffic noise in accordance with the duty to adopt the best practicable option.

1.1.2 This Standard is intended to be used primarily by local authorities, and road controlling authorities, as well as developers who are constructing or altering roads as part of a subdivision or land-use development. The Environment Court and Boards of Inquiry may also take the Standard into account when considering applications and notices or requirement for major transport projects. The Standard seeks to promote consistent decision-making on road-traffic noise in the design of new and altered roads.

1.1.3 This Standard is intended to be suitable for citing in planning and policy documents prepared under the Resource Management Act (RMA) as the basis for measurement, prediction, assessment, and mitigation of noise from new and altered roads and for the guidelines within the Standard to be applied in the formulation of RMA plan content, and conditions of designations and resource consents.

1.1.4 The criteria in this Standard are intended to aid in the design of new and altered roads by setting reasonable criteria for the road-traffic noise from new or altered roads taking into account health issues associated with noise, the effects of relative changes in noise levels on people and communities, and the potential benefits of new and altered roads to people and communities.

1.2 APPLICATION

1.2.1 Subject to the limitations set out in 1.3, this Standard applies to all new and altered roads as defined in 2.2, and assessed in accordance with section 7.

1.2.2 This Standard establishes the following principles:

(a) New and altered roads shall be designed and constructed so that noise effects are mitigated to a reasonable level in accordance with the provisions of this Standard and in particular the criteria in section 6;

(b) Planning and designing new and altered roads should be undertaken so that external levels of road noise are kept at reasonable levels at as many PPFs as is consistent with the adoption of the best practicable option for noise mitigation; and

(c) For the purposes of noise mitigation, and subject to the need for road controlling authorities and developers to adopt the best practicable option:
  (i) The preferred mitigation method is structural mitigation measures within road corridors
  (ii) The second preference is for external structural mitigation measures to be constructed on land outside road corridors, and
  (iii) The least preferred option is acoustical insulation of habitable spaces in PPFs.

1.2.3 For the purposes of this Standard:

(a) Clause 8.2.2 should be considered to find the minimum noise-reduction requirement for structural mitigation measures;
(b) In applying the noise criteria in this Standard to any new or altered road, the assessment process described in section 7 shall be undertaken;
(c) Subject to 1.3.1(d) and 1.3.1(e), this Standard shall apply to all PPFs near a new road where the noise at any one or more PPFs is predicted to increase by 3 dB $L_{Aeq(24h)}$ or more at the design year when compared with the existing noise environment;
(d) Subject to 1.3.1(d) and 1.3.1(e), this Standard shall apply to all PPFs near an altered road where one or more PPF for that altered road exceeds one of the thresholds in 1.5.2;
(e) Where any project includes a mixture of new and altered roads the road controlling authority or developer that proposes to construct the project shall determine which particular section of road is a new road or an altered road;
(f) The road controlling authority or developer constructing a new or altered road shall determine the design year which applies to that particular new or altered road;
(g) Annual average daily traffic (AADT) values shall be based on field measurement counts of vehicles traversing a nominated road or road section or predicted vehicle counts applying to an existing or future road or road link that are obtained from a validated traffic model or based on appropriate traffic growth rates;
(h) AADT values shall be accompanied by a stated year value, being the 12-month period for the AADT value.

C1.2.3 *When assessing the noise effects associated with an altered road, an important consideration is the extent of the predicted increase in the external sound level at the design year arising from alterations to an existing road (do-minimum noise environment) when compared to the external sound level at the design year that would be present if no alterations were undertaken (do-nothing environment).*

The same issue applies to new roads but relates to the predicted comparative increase between the do-minimum noise environment and the existing sound level (existing noise environment) since a new road will not have a do-nothing environment.

The New Zealand Transport Agency 'Economic evaluation manual' provides procedures for the validation of traffic models and provides default traffic growth rates.

1.2.4 Where the application of sufficient mitigation measures to achieve the criteria set out in section 6 at the assessment positions of all PPFs is not consistent with adopting the best practicable option, mitigation measures shall be implemented to achieve a target noise level as close to those criteria as is consistent with the adoption of the best practicable option (see table 2).

C1.2.4 *Practical considerations mean abrupt changes in noise criteria should be avoided.*

The best practicable option for mitigating the adverse effects of noise includes consideration of the financial implications and the current state of technical knowledge as well as of other factors such as safety issues and visual effects (see 6.3).

Reasonable criteria for measuring road-traffic noise are used for the criteria for designing new or altered roads. These criteria are to be used as guidance for road controlling authorities and local authorities. Examples of applying the criteria are given in Appendix A.

1.3 LIMITATIONS

1.3.1 This Standard does not apply to:

(a) Existing roads;

(b) New and altered roads predicted to carry less than 2000 AADT at the design year;

(c) Alterations to existing roads that are not altered roads as defined in this Standard;

(d) PPFs located in urban areas and located more than 100 m from the edge of the closest traffic lane for the new or altered road;

(e) PPFs located in rural areas and located more than 200 m from the edge of the closest traffic lane for the new or altered road;

(f) The control of noise generated by an individual vehicle;

(g) Noise from the construction or maintenance of roads (refer to NZS 6803);

(h) Vehicle-induced ground-borne vibration;

(i) Vehicle noise from land that is not a road (refer to NZS 6802);

(j) The development of PPFs or other noise-sensitive activities which can give rise to reverse sensitivity effects;

(k) Private ways;

(l) Premises other than PPFs (see 1.4);

(m) The building of new roads or alterations to existing roads when the building or alteration of the road is a permitted activity in the relevant district plan, whether that road is designated and the permitted activity performance standards in the plan do not require this Standard to be applied;

(n) New and altered roads that are designated in the relevant district plan and at the time of designation, mitigation of road noise was provided for by a condition or conditions (other than by any condition requiring this Standard to be applied).

C1.3.1 *Noise criteria recommended in this Standard are not intended to apply to low volume roads, for example those in isolated rural areas servicing a small number of dwellings, agricultural industries, or other commercial or business activities which generate low traffic volumes. In these circumstances resource consent conditions controlling hours of operation and number of vehicles may be more appropriate.*

It is not feasible to predict the ambient sound level at the design year for a new road. Instead 1.3.1(d) compares the predicted noise increase from a new road with the existing noise environment.

1.3.2 An automated web-based screening procedure, suitable for determining whether or not this Standard is likely to apply to a given roading project or activity, is available on the New Zealand Transport Agency transport noise website at www.acoustics.nzta.govt.nz.

The screening procedure is designed for use by non-noise specialists and is intended to help ensure that roading projects that fall outside the scope of this Standard, for example because the project does not fall within the definition of 'altered road', or because the project is a new road unlikely to result in an increase of 3 dB $L_{Aeq(24h)}$ or more at the design year at any PPF, are not subject to unnecessary noise-assessments.

1.4 PROTECTED PREMISES AND FACILITIES

1.4.1 This Standard applies to a limited range of PPFs used for noise-sensitive activities. Subject to 1.4.2 and 1.4.3, PPFs include:

(a) Buildings used for residential activities including:
  (i) Boarding establishments
  (ii) Homes for elderly persons
  (iii) Retirement villages
  (iv) In-house aged-care facilities, and
  (v) Buildings used as temporary accommodation in residentially zoned areas, including hotels and motels, but excluding camping grounds;
(b) Marae;
(c) Spaces within buildings used for overnight patient medical care; and
(d) Teaching areas and sleeping rooms in buildings used as educational facilities including tertiary institutions and schools, and premises licensed under the Education (Early Childhood Services) Regulations, and playgrounds which are part of such facilities and located within 20 m of buildings used for teaching purposes.

PPFs do not include:

(e) Residential accommodation in buildings which predominantly have other uses such as commercial or industrial premises;
(f) Garages and ancillary buildings; and
(g) Premises and facilities which are not yet built, other than premises and facilities for which a building consent has been obtained which has not yet lapsed.

> ***C1.4.1*** *Applying the criteria set out in section 6 to PPFs can incidentally provide a degree of acoustic protection to outdoor spaces in their vicinity.*
>
> *This Standard attempts to remove any connection between when something is a PPF and the authorisation of a roading project. It does however, provide a degree of protection for situations where a building consent has been granted, but not yet implemented. The Standard also recognises that land-use planning is the preferred tool to manage the location of PPFs in relation to previously authorised roading projects.*

1.4.2 The first RMA authorisation obtained for the construction of a new or altered road should identify the PPFsaffected by that new or altered road. An RMA authorisation should include PPFs that have already been built and any PPFs for which a building consent has been obtained which has not lapsed (even if they have not yet been built).

Where PPFs are identified in the first RMA authorisation obtained for the construction of a new or altered road, for the purposes of this Standard those identified PPFs shall be the PPFs in relation to that new or altered road for all future applications of this Standard to that new or altered road.

C1.4.2 For example, subject to 1.3.1(n), where there is a designation for an existing road which was obtained before this Standard was published, and alterations to that existing road do not require an alteration to the designation under section 181 of the RMA but do require an outline plan under section 176A of that Act, that outline plan would, for the purposes of this Standard, be the first RMA authorisation for that altered road.

Where the first RMA authorisation for a new or altered road identifies the PPFs in relation to that new or altered road and a noise-sensitive activity that is not identified in the RMA authorisation is established in proximity to the site of the new or altered road, that activity will for the purposes of this Standard, not be a PPF in relation to that new or altered road.

1.5 ALTERED ROAD

1.5.1 This Standard applies only to limited types of roading projects.

1.5.2 Subject to 1.5.4, an altered road means an existing road that is subject to alterations of the horizontal or vertical alignment where at any assessment position at any one or more PPF:

(a) The do-minimum noise environment would be greater than or equal to 64 dB $L_{Aeq(24h)}$ and, if no specific noise mitigation was undertaken, the alterations would increase road-traffic noise at that assessment position by 3 dB $L_{Aeq(24h)}$ or more at the design year, when compared with the do-nothing noise environment; or

(b) The do-minimum noise environment is greater than or equal to 68 dB $L_{Aeq(24h)}$ and, if no specific noise mitigation was undertaken, the alterations would increase road-traffic noise at that assessment position by 1 dB $L_{Aeq(24h)}$ or more at the design year, when compared with the do-nothing noise environment.

C1.5.2 Section 1.5.2 (a) means this Standard does not apply where alterations to an existing road are predicted to increase the do-minimum noise environment compared with the do-nothing noise environment, by less than 3 dB $L_{Aeq(24h)}$. For a change of exactly 3 dB $L_{Aeq(24h)}$, the do-nothing noise environment for consideration would therefore be 61 dB $L_{Aeq(24h)}$ since the most stringent external noise criterion is 64 $L_{Aeq(24h)}$. For a change greater than 3 dB $L_{Aeq(24h)}$ a lower do-nothing noise environment may be relevant if the do-minimum noise environment is 64 $L_{Aeq(24h)}$ or more.

1.5.3 This Standard shall be applied to all PPFs described in 1.4 providing one or more of the thresholds specified in 1.5.2 are exceeded at one or more PPFs.

1.5.4 An altered road does not include the following alterations to the horizontal or vertical alignment of an existing road:

(a) Resurfacing;

(b) Surface treatment;

(c) Rehabilitation.

C1.5.4 Alterations of the kind described in 1.5.4 are mostly associated with the maintenance of existing roads. Such works may cause an incidental increase in noise but are outside the scope of this Standard.

1.6 NEW ROAD

A new road is any road which is to be constructed where no previously formed legal road existed. A new road excludes any existing road and any altered road but includes the formation of any previously unformed legal road.

1.7 ASSESSMENT POSITION

1.7.1 For any existing building, the assessment position means the exterior wall most affected by noise from the new or altered road being assessed and is 1.2 – 1.5 m above each floor level of interest in the building. The assessment shall be based on sound incident on the building at this position not including reflections from the wall being assessed, so that the sound level assessed is equivalent to a free-field sound level.

1.7.2 For any proposed building this means a free-field location that is representative of the exterior wall that will be most affected by noise from the new or altered road being assessed and is 1.2 – 1.5 m above each floor level of interest in the building.

1.7.3 For any playground which falls within the definition of 'protected premises and facilities' set out in 1.4, this means a free-field location that is representative of the most exposed position on the playground to noise from the new or altered road being assessed and is 1.2 – 1.5 m above the mean ground level (refer to NZS 6801).

C1.7 Assessment position

To avoid confusion, references to sound levels near buildings are taken to be equivalent to a free-field sound level. Reflections of sound from more or less vertical wall surfaces, or outdoor ceilings such as verandas, and large soffits, will increase the sound received if microphone positions are, or assumed to be, within a few metres of buildings.

Reflections from the ground are ignored. Measurements made 3.5 m or more away from the building are taken to be free of influence of reflected sound from a building and this is known as a free-field location. If the assessment position is within 3.5 m of the building surface, a façade correction is required to calculate an equivalent free-field sound level (see also C5.2.1.5).

Figure C1.1 provides examples of assessment and measurement positions for guidance. Figure C1.1(b) shows an example of an existing building sufficiently set back to enable the measurement position to be between the existing building and the road. If the distance between the measurement position and the building is less than 3.5 m, a façade correction would be required to calculate the sound level at the assessment position.

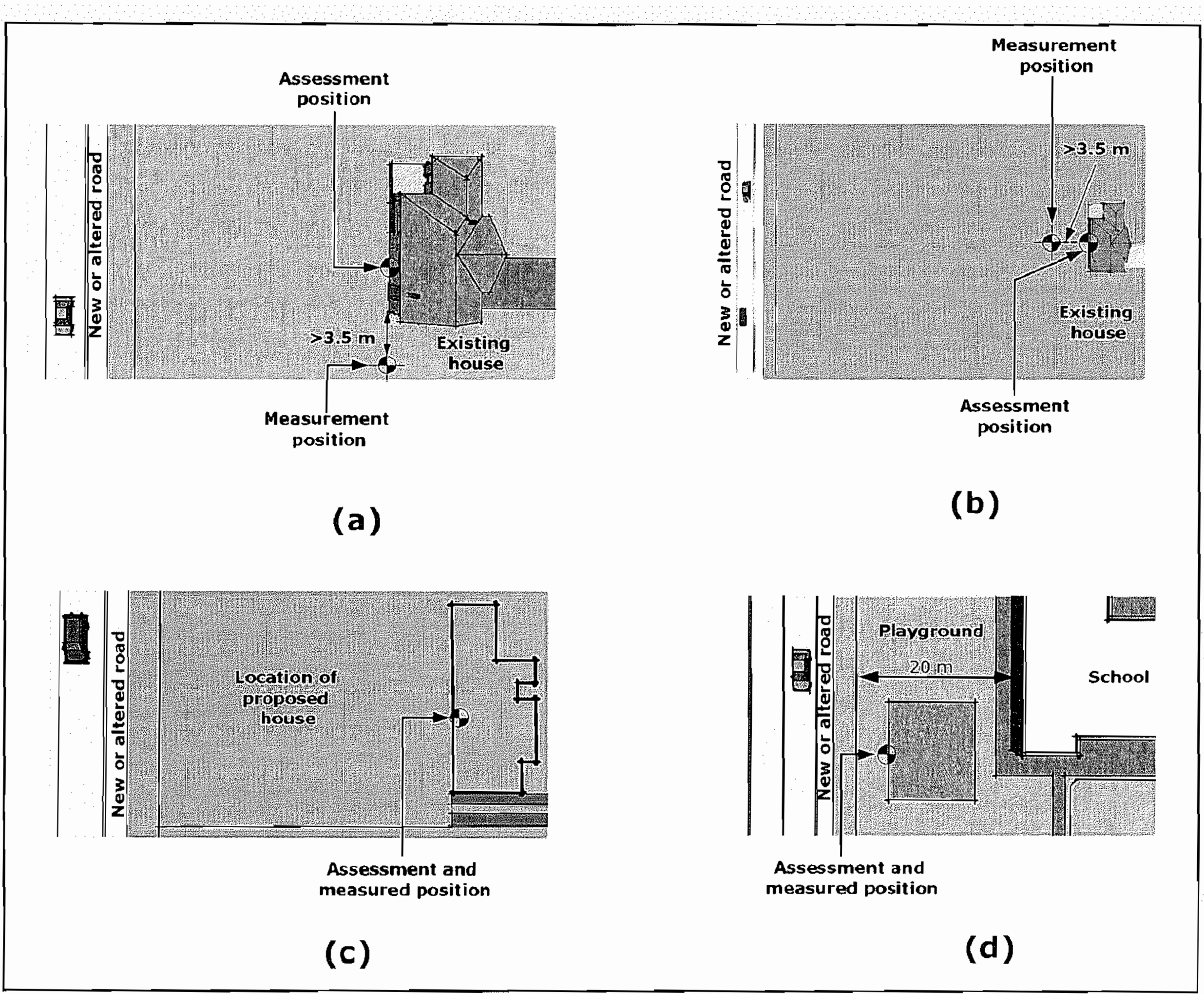


Figure C1.1 – Examples of assessment and measurement positions

1.8 USER RESOURCES

Tools, templates, and other resources intended to assist users of this Standard are available (refer www.acoustics.nzta.govt.nz).

2 INTERPRETATION

2.1 TERMINOLOGY

For the purposes of this Standard, the word 'shall' refers to requirements that are essential for compliance with the Standard, while the word 'should' refers to practices that are advised or recommended.

Clauses prefixed 'C' and printed in italic type are intended as comments on the corresponding clauses. They are not to be taken as the only or complete interpretation. The Standard can be complied with if the comment is ignored.

The term 'Informative' has been used in this Standard to define the application of the Appendix to which it applies. An 'Informative' Appendix gives additional information, and is only for guidance. It does not contain requirements.

2.2 DEFINITIONS

In this Standard, unless the context requires otherwise, the following definitions shall apply:

Altered road	Has the meaning set out in 1.5
Ambient sound	The totally encompassing sound in a given situation at a given time, from all sources near and far including any specific sound (refer to NZS 6801)
Annual average daily traffic (AADT)	The vehicle count for an entire year in both directions past a point on the road, divided by the number of days in the year
Assessment position	Has the meaning set out in 1.7
Best practicable option	Has the same meaning as in section 2(1) of the Resource Management Act. Matters which should be considered when determining the BPO for mitigating road-traffic noise from a new road or altered road on the assessment position of a building of any protected premises or facilities are set out in 6.3 of this Standard
Building-modification mitigation	Measures designed to reduce the internal traffic noise levels at protected premises and facilities which involve changes to buildings. Such mitigation includes the following measures: (a) Acoustic insulation; (b) Voice amplification systems; and (c) Building relocation Building-modification mitigation does not include building design and layout options, which can also be used to reduce the effects of internal traffic noise levels
Cluster	(a) Except as provided in paragraph (b) of this definition, a minimum of three protected premises and facilities that are assessed in accordance with this Standard that: (i) Are on the same side of the new or altered road being assessed (ii) Each have at least one assessment position that is within 100 m of an assessment position at one of the other protected premises or facilities in the same group; (b) Any teaching or medical facility as set out in 1.4.1

dBA	See Time-average A-weighted sound pressure level
decibel (dB)	The term used to identify 10 times the logarithm to the base 10 of the ratio of two like quantities proportional to intensity, power, or energy
Design year	A point in time that is not less than 10 years but not more than 20 years after the opening of a new road, or the opening of alterations to an altered road, to the public
Do-minimum noise environment	The predicted road traffic noise level at the assessment position(s) of protected premises and facilities at the design year, with the project implemented including safety barriers and other structures, which may provide incidental noise mitigation. The do-minimum noise environment does not include any mitigation measures that would be undertaken for the sole purposes of reducing noise effects
Do-nothing noise environment	The predicted road traffic noise level at the assessment position(s) of protected premises and facilities at the design year assuming no alterations are made to the existing road
Emission	Sound emitted from a source or sources at a defined location
Existing noise environment	The ambient sound levels at the assessment positions of protected premises and facilities at the date of an assessment carried out under this Standard
Existing road	A road that is a formed legal road at the time when the noise effects of a new or altered road are assessed in accordance with this Standard. The term 'existing road' does not include an unformed legal road
Free-field location	A location at least 3.5 m from any significant reflecting surface other than the ground
Habitable space	A space used for activities normally associated with domestic living, but excluding any garage, bathroom, laundry, toilet (water closet), pantry, walk-in wardrobe, corridor, hallway, lobby, clothes-drying room, or other space of a specialised nature occupied neither frequently nor for extended periods
$L_{10\,(18h)}$	The A-frequency-weighted centile level equalled or exceeded for 10% of an 18-hour measurement time interval. It is determined from measured or predicted A-frequency-weighted F-time weighted sound pressure level, or A-frequency-weighted, short-LEQ. $L_{10\,(18h)}$ may also be written as $L_{A10\,(18h)}$ and is the basic noise descriptor used for traffic on a length of road in the Calculation of Road Traffic Noise (CoRTN) prediction procedure (refer to United Kingdom Highways Agency 2008)
LEQ or Leq (Leq (t))	See Time-average A-weighted sound pressure level
Legal road	Land which the public has a right to pass along at all times, and includes a local road and a state highway (including a motorway as that term is defined in section 2(1) of the Government Roading Powers Act
Measurement time interval	The duration of a single measurement
New road	Has the meaning set out in 1.6

Noise	Noise arising from vehicles travelling on roads, including road/tyre interaction noise. It does not include rail noise, port noise, aircraft noise, or noise from any other sources such as industrial activities or road construction and maintenance
Noise criteria	A time-average sound level established in this Standard which can be stated in a rule, plan, condition of resource consent designation or any National Environmental Standard. Similar to a noise limit (see section 6)
Plan	Any district, regional, or regional coastal plan under the Resource Management Act and includes any proposed plan, plan change, or variation to a proposed plan
Private way	Any way or passage over private land the right to use which is confined, or intended to be confined, to certain persons or classes of persons, and which is neither open, nor intended to be open, to the use of the public
Protected premises and facilities (PPFs)	Has the meaning set out in 1.4
Reverse sensitivity	The vulnerability of an established activity to objection from a new sensitive land use
Resource Management Act (RMA) authorisation	A designation, an alteration to a designation, an outline plan, or a land-use resource consent
Road	See Legal road
Road controlling authority	Has the same definition as in section 5 of the Land Transport Management Act
Rural environment	An area which is not an urban environment as defined in this Standard
Sound level	Ten times the logarithm, to the base 10, of the ratio of the average of the square of the A-frequency-weighted sound pressure over a specified period of time, to the square of the reference value. The time interval for every LEQ measurement shall be stated
Sound pressure level (Lp)	Ten times the logarithm to the base 10 of the ratio of the square of the sound pressure to the square of the reference value (20 μPa) $L_p = 10\ \lg\left(p^2/{p_0}^2\right)$ .... Equation 1 where: p is the sound pressure in pascals p_0 is the reference value, 20 μPa
Standardised level difference	A single value used to describe the acoustic performance of the external building envelope (including windows, walls, ceilings, and floors where appropriate) Standardised level difference shall be described using D_{nTw} + C_{tr} as defined in ISO 717-1 using spectrum number 2 (A-weighted traffic noise spectrum) The C_{tr} correction term shall be included within the rating method to ensure these methods adequately consider low frequency sounds associated with road-traffic

Structural mitigation

Measures designed to reduce the external traffic noise levels at protected premises and facilities. Such mitigation includes the following measures:

(a) Low-noise road surface materials;
(b) Noise barriers (including noise walls); and
(c) Noise bunds (including earth berms and mounds).

Structural mitigation does not include the following measures, which can also be used to reduce the effects of external traffic noise levels:

(d) Road gradient options;
(e) Traffic demand management;
(f) Property purchase;
(g) Separation distances;
(h) Solid safety barriers unless they are being specifically installed as a noise barrier; and
(i) Building modification

Time-average A-weighted sound pressure level ($L_{Aeq(24h)}$)

Ten times the logarithm, to the base 10, of the ratio of the average of the square of the A-frequency-weighted sound pressure over a specified period of time, to the square of the reference value. The time interval for every LEQ measurement shall be stated

$$L_{Aeq(t_3)} = 10 \lg \left(\frac{1}{t_3} \int_{t_1}^{t_2} p_A{}^2(t)\, \mathrm{dt} \Big/ p_0{}^2 \right) \text{ .... Equation 2}$$

Where:

t_3 is the measurement time interval between start and finish times t_1 and t_2
$L_{Aeq(t_3)}$ is the LEQ over time period t_3
$p_A{}^2(t)$ is the square of the A-frequency-weighted sound pressure as a function of time
p_0 is the reference value, 20 μPa

NOTE – $L_{Aeq(24h)}$ is the descriptor in this Standard for road-traffic noise.

Urban environment

A main urban area, a satellite urban community, or an independent urban community (Statistics New Zealand 2004)

Vehicle

As defined in section 2(1) of the Transport (Vehicle and Driver Registration and Licensing) Act

Weighting

The introduction of an electronic process to modify the response of a sound level meter in accordance with relevant IEC Standards, for example, F-time weighting or C-frequency weighting

2.3 SYMBOLS

2.3.1 Quantities

The quantities and symbols used in this Standard are listed in table 1.

Table 1 – Symbols for sound quantities

Quantity	Symbol	Acceptable typed expression
24 hour average sound level	$L_{Aeq(24h)}$	LEQ (24h) or (Leq (24h))
$L_{10\ 18\ hour}$ centile level	$L_{A10(18h)}$	L10 (18h)
Time-average sound level	$L_{Aeq(t)}$	LEQ (t) or (Leq (t))
Standardised level difference, traffic	$D_{2m,nT(}C_{tr,\ 50\text{-}5000)}$	$D_{nTw,}$ (traffic)

2.3.2 Notation

In accordance with international conventions, where a sound level is A-frequency weighted this shall be denoted by an 'A' subscript in the descriptor for example, $L_{Aeq(24h)}$. Previous conventions of adding an 'A' to the units (for example, dBA) shall not be used when reporting sound levels in accordance with this Standard. Sound levels shall be reported in the format 'value unit descriptor' for example, 68 dB $L_{Aeq(24h)}$.

2.4 ABBREVIATIONS

The following abbreviations are used in this Standard:

AADT	Annual average daily traffic
AC	Asphaltic concrete
AEE	Assessment of the environmental effects
BCR	Benefit-cost ratio
CoRTN	Calculation of road traffic noise
EEM	Economic evaluation manual
HCV	Heavy commercial vehicles
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
NZBC	New Zealand Building Code
NZTA	New Zealand Transport Agency
NZTS	New Zealand Transport Strategy
OGPA	Open graded porous asphalt
PPF	Protected premises and facilities
RMA	Resource Management Act
SMA	Stone mastic asphalt
vpd	Vehicles per day
WHO	World Health Organization
WoF	Warrant of Fitness

3 DESCRIPTION OF ROAD-TRAFFIC NOISE

3.1 DESCRIPTOR OF ROAD-TRAFFIC NOISE

The descriptor in this Standard for road-traffic noise is the 24-hour average sound level, $L_{Aeq(24h)}$.

3.2 NATURE OF ROAD-TRAFFIC NOISE

3.2.1 Noise is unwanted sound. The characteristics of sound determine its intrusiveness and its effects. Road-traffic noise consists of three key components:

(a) Mechanical noise, including engine, exhaust, and induction noise;
(b) Rolling noise – tyre/road interaction; and
(c) Aerodynamic noise.

C3.2.1 *Faulty or modified exhausts and vehicle-braking systems in heavy vehicles are a common source of noise, particularly of peak noise events. The level of tyre/road noise is affected by the design of the tyre and the type of road surface, and also if the surface is wet or dry. Aerodynamic noise is noise from rapid movement of a vehicle through the air and can sometimes create whistling, flapping, or humming noises, particularly if there is external cargo on the vehicle. Other mechanical noises include rattling of empty trucks, and engine braking by heavy vehicles.*

3.2.2 For vehicles travelling at low speeds, noise is predominantly caused by vehicle sources such as the engine including the cooling fan, transmission, and intake and exhaust systems. For vehicles travelling more than approximately 50 km/h, tyre/road noise is the predominant source.

C3.2.2 *The actual speed at which tyre/road noise becomes the dominant noise source varies according to the type of vehicles (light or heavy) using a road (see Appendix B for further information).*

3.2.3 Noise may be continuous, for example, noise from a busy urban motorway or an arterial road, or it may be intermittent, for example, truck noise from a rural road at night.

C3.2.3 *The actual level of noise audible in a particular location will depend upon a range of factors, for example:*

(a) Composition of traffic – proportion of heavy, noisy, or older vehicles;
(b) Traffic conditions – such as vehicle speed and traffic flow;
(c) Driver behaviour – such as the amount of acceleration and braking;
(d) Type of road surface – such as texture and porosity;
(e) Grade of the road – such as the extent of inclines; and
(f) Surrounding topography – such as the elevation of the road above surrounding ground, or a road running through a gully.

3.3 EFFECTS OF NOISE

3.3.1 The impact of noise on people and communities can range from general interference with everyday activities through to more significant health impacts. High noise exposure can create stress-type responses and sleep disturbance is a common complaint from people affected by night-time noise. Other potential noise effects include speech interference, annoyance, reduced work performance, impaired learning, and some research indicates that over the longer term noise-induced stress can lead to hypertension and heart disease.

3.3.2 The noise criteria contained in section 6 of this Standard are designed to set reasonable criteria for the road-traffic noise from new or altered roads taking into account health issues associated with noise, the effects of relative changes in noise levels on people and communities, and the potential benefits of new and altered roads to people and communities.

3.4 SINGLE-EVENT NOISE AND QUANTIFYING TRAFFIC NOISE

3.4.1 Driver behaviour and abnormal vehicle characteristics will mean some individual vehicle noise will be prominent in traffic flow and this may increase intrusiveness. Enforcement of vehicle noise emission standards and driver behaviour is outside the jurisdiction of road controlling authorities and this Standard cannot control such noise.

3.4.2 People's response to noise from traffic flows less than 2000 AADT is mostly to individual vehicle noise as a transient maximum sound level. Above this AADT, the response is more to the combined sound level of the traffic flow. This combined traffic noise can be quantified by the time-average sound level $L_{Aeq(t)}$ for any selected time period, which in this Standard is 24 hours.

4 LEGAL AND POLICY CONTEXT

4.1 INTRODUCTION

This Standard incorporates guidelines for good practice assessment approaches for projects which are intended to identify any potential noise effects on people and communities and assess appropriate mitigation measures against criteria relevant to the RMA and other relevant legislation and policy frameworks.

NZS 6806 operates in the context of national policy direction and other statutory policy and planning documents such as regional policy statements, regional land transport strategies, regional and district plans, and statutory authorisations such as designations and resource consents. By addressing the issue of compatibility between noise-sensitive activities and natural and physical resources related to transport infrastructure that produces noise, this Standard is consistent with the approach taken in existing acoustical Standards, for example, those relating to airports and ports.

The Standard is one of a number of workstreams defined by the Government in 2006 to address land transport noise in a more integrated manner. Completion of the Standard was also identified as a key short-term action in the New Zealand Transport Strategy (NZTS).

C4.1 *Concern about noise remains one of the most common public objections to new transport infrastructure projects. Noise issues can be exacerbated when new noise-sensitive development is located in areas already exposed to significant transport noise. This is commonly referred to as reverse sensitivity.*

Individual vehicle noise is a significant concern for many people living adjacent to roads. This is particularly so for night-time noise events, either from heavy vehicles or vehicles that are being driven inappropriately or have been modified. While procedures under this Standard may give some incidental benefit for these circumstances, warrant of fitness requirements and other vehicle regulations are the primary methods for managing noise from these vehicles (see Appendix B for further information).

4.2 NEW ZEALAND TRANSPORT STRATEGY

The NZTS was originally launched in 2002 and updated in 2008.

The strategy includes two objectives and associated outcome statements that are relevant to the management of road-traffic noise.

(a) 'Protecting and promoting public health'. The desired trend sought is reflected in the outcome statement 'negative impacts of transport are reducing in terms of fatalities, injuries and harm to health'.

(b) 'Ensuring environmental sustainability'. The desired trend sought is reflected in the outcome statement 'negative impacts of transport are reducing in terms of the human and natural environments'.

The following transport noise target is included in the strategy to provide more specific direction to the transport sector:

'Reduce the number of people exposed to health-endangering noise levels from transport'.

The strategy also identifies that land-use development and its impact on transport demands is a key challenge. Once development has happened, its impacts on transport are long-term, so it is essential that urban or other growth does not place excessive costs on the transport sector or expose communities to unreasonable noise.

C4.2 Other government strategies relevant to the management of road-traffic noise include energy, public health, and research.

4.3 LAND-USE PLANNING

This Standard includes guidance that is intended to be used in land-use planning processes as one element in closer integration of road transport regulation under the RMA, the Land Transport Management Act, and the Local Government Act.

Land-use patterns can have important long-term influences on exposure to noise in transport corridors. It is therefore important that processes for planning land use and transport are well integrated in order to support the strategic management of noise.

The NZTS outlines the Government's approach to integrated planning which is to build upon the extensive base of existing good practice and develop further guidance for the transport sector on sustainable urban design.

4.4 LAND TRANSPORT MANAGEMENT ACT

4.4.1 The purpose of the Land Transport Management Act is to contribute to the aim of achieving an affordable, integrated, safe, responsive, and sustainable land transport system. The Ministry of Transport and the New Zealand Transport Agency (NZTA) work in partnership with the Environmental Protection Authority, regional and territorial authorities, road controlling authorities, the transport industry, and communities in order to fulfil this purpose.

4.4.2 This Standard incorporates guidelines for good practice on approaches to assessing roading projects. These good practice guidelines are intended to be consistent with other relevant legislation and policy frameworks.

C4.4.2 The Land Transport Management Act requires a government policy statement to be issued which, among other things, provides guidance on the short to medium-term impacts, that the Government wishes to address from the allocation of the national land transport fund. The NZTA is required to prepare and adopt a National Land Transport Programme every 3 years. In preparing that programme the NZTA is required to ensure that the programme contributes to the aim of achieving an affordable, integrated, safe, responsive, and sustainable land transport system and is required to take into account (among other things) regional land transport strategies.

4.5 RESOURCE MANAGEMENT ACT

4.5.1 At a local level, the RMA assigns the functions of the control of the emission of noise and the mitigation of the effects of noise to:

(a) Territorial authorities within their districts; and
(b) Regional councils (in conjunction with the Minister of Conservation) within any parts of the coastal marine area within their regions.

4.5.2 This Act empowers road controlling authorities, either as local authorities or network utility operators which have been approved as requiring authorities under the Act, to issue notices of requirement seeking to include designations for roads (including new and existing roads) and for alterations to roads in district plans. Such designations can authorise the construction, maintenance, and operation of new and altered roads.

C4.5.2 Designations cannot be obtained in order to authorise the construction or maintenance of roads in the coastal marine area. Where such activities are not authorised without the need to obtain consent under the relevant regional coastal plan(s) resource consents will be required. Certain other aspects of roading construction/alteration projects may also require resource consent from regional councils – for example, earthworks and discharges associated with a roading project, and the construction of roads in, on, under, or over the bed of any river or lake.

Road controlling authorities may also seek to alter existing designations in order to authorise the alteration of the roads which are the subject of those designations. Road controlling authorities and developers who intend to construct or alter roads as part of a subdivision or land-use development may apply for resource consents to construct, maintain, and operate new or altered roads under the relevant district or regional plans.

Alternatively, district plans and regional coastal plans may provide that the construction, maintenance or operation of certain roads can be undertaken in a particular district or part of the coastal marine area without the need to obtain resource consent (generally subject to compliance with specified permitted activity performance standards).

The Quality Planning website (http://www.qualityplanning.org.nz) includes model district plan provisions and conditions that local authorities should consider incorporating into their plans to give effect to the outcome sought by this Standard.

4.5.3 Applications for resource consent and notices of requirement for designations are required to include an assessment of the environmental effects of the proposed activity, including where relevant an assessment of potential noise effects, and a description of the mitigation measures that are proposed to be undertaken to avoid, remedy, or mitigate any adverse effects. This Standard is intended to assist with the preparation of such documentation by providing best practice guidelines.

4.6 BUILDING ACT

The New Zealand Building Code (NZBC) Clause G4 'Ventilation', contains provisions about fresh air inside buildings which is a relevant consideration when mitigating environmental sound inside buildings.

The New Zealand Building Code Clause G6 'Airborne and impact sound', contains objectives and performance requirements related to inter-tenancy noise.

4.7 HEALTH CRITERIA

4.7.1 The health of people and communities is part of sustainable management enabled by the application of the RMA. Introduction of noise criteria in this Standard recognises World Health Organization (WHO) concern about increase in traffic noise and that growth in urban environmental noise pollution is unsustainable, because it involves direct and cumulative adverse effects on health and also adversely affects future generations by degrading residential, social, and learning environments, with corresponding economic losses.

4.7.2 The noise criteria in this Standard have been selected to limit adverse effects on people of road-traffic noise above a reasonable level and health criteria, recognising as does WHO that the evaluation of control options must take into account technical, financial, social, health, and environmental factors. Approaches used in this Standard such as emphasis on land-use planning, isolation of buildings from traffic noise sources, and the selection of $L_{Aeq(t)}$ to quantify traffic noise are consistent with the advice contained in the WHO Guidelines for community noise.

5 MEASUREMENT AND PREDICTION

5.1 GENERAL

5.1.1 Measurement and prediction of noise shall be undertaken by, or under the direct supervision of, suitably qualified and experienced acousticians.

5.1.2 Methods of measurement used for investigation of environmental sound, including road-traffic noise, shall comply with NZS 6801 except where specified elsewhere in this Standard.

5.1.3 Where sound level measurements are made for the purposes of this Standard, traffic counts for the same locality and the same time period shall be made where practicable.

5.2 MEASUREMENTS

5.2.1 Measurement of road-traffic noise

5.2.1.1 Measurements may be required to quantify existing road-traffic noise, and verify noise prediction model outputs. Measurements of road-traffic noise shall be expressed as $L_{Aeq(24h)}$.

5.2.1.2 Measurements of road-traffic noise for any location shall be determined from a series of contiguous L_{Aeq} samples over a minimum of 24 hours and expressed as dB $L_{Aeq(24h)}$. Sample time intervals should be 15 minutes.

5.2.1.3 Where the requirement is for measurement of the contribution of noise from new or altered roads only, priority shall be given to measurement positions that are currently, or will be, dominated by noise from the new or altered road. Measurement positions where there is undue influence from other noise sources (for example, industrial noise) shall be avoided where practicable.

5.2.1.4 Measurements shall preferably be undertaken when road surfaces are dry. If a road surface is observed to be wet, its condition shall be reported together with a statement on the likely effect of this on measured sound levels.

5.2.1.5 Where practicable, measurements shall be undertaken at the assessment position(s) of PPFs.

C5.2.1.5 *In circumstances where PPFs do not physically exist but have building consent granted, measurements should be undertaken at representative assessment positions.*

In many cases it will be practical to measure in a free-field location to the side of or in-front of an existing building where the road-traffic noise exposure will be representative of the exposure of the building. However, it is not always possible to measure noise at such a free-field location because of the influence of substantially reflective surfaces including the building itself. In such instances, measurements can be taken 1 m from the exterior wall most affected by noise from the new or altered road being assessed. The measurements should then be reduced by 2.5 dB to take account of reflections, resulting in an estimated free-field level (this adjustment for road-traffic noise is slightly different to the 3 dB adjustment given in NZS 6801 for general environmental sound).

For guidance, figure C1.1 provides examples of assessment and measurement positions.

5.2.1.6 Other influences on measurements of road-traffic sound levels shall be reported. These can include:

(a) The type and condition of the road surfaces;

(b) Effects of traffic flow during the measurement period, considering the time of day, day of week, and proximity to atypical traffic generating events or activities. Examples include proximity to major sports events and meetings, and measurements made during periods affected by holiday travel, road works, and diversions; and

(c) Any additional acoustic effect caused by sound reflecting off vertical surfaces and received at the microphone, such as when measurements are conducted at assessment locations in front of buildings.

> ***C5.2.1.6*** *Measurement of noise can be at locations exposed to significant noise from non-road-traffic sources and precautions should be taken against contamination of measurements arising from extraneous noise sources. Refer to NZS 6802 for advice on methods of determining and estimating the sound level attributable to the source of interest, in this case road-traffic noise. As traffic flow is typically correlated to the sound level, traffic noise can be predicted from data on traffic counts related to site conditions.*

5.2.2 Measurement of ambient sound

5.2.2.1 *Introduction*

The purpose of measuring ambient sound levels is to quantify, in acoustical terms, the existing noise environment at a location of interest. This will include typical variations in sound levels throughout the day and night, taking into account the existing sound sources in the vicinity of the location such as noise from near and distant transportation and industrial sources, sounds from other human activities, and natural sounds.

> ***C5.2.2.1*** *In rural areas, a single, well-chosen site may be representative of an area of many hectares. In urban areas more locations may need to be selected. Additional sites may also be required in hilly terrain to adequately represent the sound environment because of localised shielding affecting propagation of sound caused by, for example, topography, cuttings, barriers, or other features.*
>
> *In urban areas near major roads the ambient sound level is largely controlled by noise from traffic on roads, both nearby and more distant. It is important to carry out ambient sound surveys over periods that are representative of typical conditions.*

5.2.2.2 *Measurements*

Measurements of ambient sound should be undertaken for all new or altered roads.

5.2.2.3 *Measurement time intervals*

Measured ambient sound levels for any location shall be determined from a series of contiguous L_{Aeq} samples over a minimum of 24 hours and expressed as dB $L_{Aeq(24h)}$. Sample time intervals should be 15 minutes.

> ***C5.2.2.3*** *It is usually impractical to make measurements over long time intervals such as months. If existing traffic noise is a significant influence on ambient sound level, it is necessary to choose time intervals in which traffic flow patterns are typical. Weather conditions should be monitored to ascertain any effects upon propagation between the road and the assessment position.*

5.2.2.4 *Measurement locations*

Measurement locations should be typical of an area under study; and

(a) Avoid locations with higher than typical sound exposure for the locality;

(b) Not be shielded by buildings or local topography from significant sound sources;

(c) Be at least 10 m from any existing or proposed road kerb unless circumstances dictate otherwise;

(d) Be sufficient in number to enable the sound environment of an area to be adequately assessed and described;

(e) Where practicable, be at the assessment position(s) of PPFs.

C5.2.2.4 *In sparsely occupied areas, the ambient sound level is more often determined by natural noise sources such as wind, insects, or surf. In these situations ambient sound levels can vary over a wide range according to prevailing conditions. Discrete measurements of ambient sound over several days duration may be necessary to obtain representative values of varying conditions (refer to NZS 6802).*

Examples of assessment and measurement positions are provided in figure C1.1.

5.2.3 Measurements of indoor sound

5.2.3.1 Reduction of noise received indoors depends upon the airborne sound insulation of buildings. Methods used in this Standard to assess the degree to which external noise is reduced when transmitted through the external building envelope shall take into account the frequency dependence of the building elements for the spectra of the incident road traffic noise.

C5.2.3.1 *The frequency spectrum characteristic of road-traffic noise is part of the rating method.*

5.2.3.2 For assessment of internal noise this Standard requires the acoustic insulation performance of buildings to be specified and, where necessary, rated using the 'standardised level difference' which describes the acoustic performance of the external building envelope (including windows, walls, ceilings, and floors where appropriate).

C5.2.3.2 *Noise received inside buildings should be quantified by using the 'standardised level difference' which is a single figure value representing the characteristics of the building structure, the location of any openings and the rating of any acoustically weak elements such as windows. Care should be taken when assessing indoor levels to ensure that the effects of separation distance, noise barriers, and building orientation on external sound levels are included.*

5.2.3.3 In circumstances where it is necessary to assess the acoustic insulation performance of the building, field tests of the standardised level difference shall be performed using ISO 140-5.

C5.2.3.3 *Field testing using ISO 140-5 can be time consuming and costly. An approximate estimate of the standardised level difference using* $D_{nT,w} + C_{tr}$ *rating can be obtained by examining the sound level difference between simultaneous indoor and outdoor measurements (excluding any influence of non-traffic related sources).*

5.3 PREDICTION

5.3.1 Introduction

Noise assessments are typically undertaken using noise modelling that enables predictions to be made of noise arising from complex road networks. Most models are capable of taking into account a large variety of factors that can influence noise generation and propagation. Various computer modelling programs are available.

5.3.2 Modelling

For the purposes of this Standard, any noise-modelling software used should meet the following criteria:

(a) Be established and internationally recognised;

(b) Have an accuracy based on field tests demonstrating that the predicted level does not vary from the measured level by more than ± 2 dB at the 95% confidence interval;

(c) Have the capability of predicting road-traffic sound levels in accordance with the United Kingdom Department of Transport and Welsh Office 'Calculation of road traffic noise (CoRTN)', and enable adjustments to be made in accordance with the requirements of the Land Transport New Zealand research report 326' and annex 4 of the United Kingdom Highways Agency 'Design manual for Roads and Bridges HA 213/08'; or

(d) Have the capability of predicting road-traffic noise levels in accordance with other internationally recognised procedures, tested and validated for New Zealand conditions.

C5.3.2 *International noise modelling programmes generally do not include the adjustments identified in the Land Transport New Zealand research report 326, as those adjustments are specific to New Zealand. Any noise modelling software used should permit relevant adjustments to be incorporated. Reference should also be made to Transfund 'Research report 121'.*

5.3.3 Noise-model inputs

Inputs to computer models should include the following data:

(a) Traffic flows appropriately distributed over traffic lanes;

(b) Heavy vehicle percentage;

(c) Road gradient;

(d) Road surface;

(e) Horizontal and vertical road alignment;

(f) Average vehicle speed (not posted speed limit if different from average);

(g) Terrain data having ground contour intervals not exceeding 5 m and extending for a distance of 50 to 200 m either side of the outside edges of the carriageway, or such other distance as required to encompass locations containing PPFs;

(h) The location and dimensions of any existing and proposed solid roadside barriers installed for noise mitigation, safety, or other purposes; and

(i) Buildings and other structures that may affect propagation of noise.

In situations where the road layout is uncomplicated, for example, only two traffic lanes (one in each direction), there is relatively flat terrain, and where there are a small number of PPFs, traffic noise may be predicted manually or by the use of computer programs.

5.3.4 Project-model calibration

5.3.4.1 Modelling of existing ambient sound levels should be compared with measured levels for model calibration purposes where practicable.

5.3.4.2 The difference between measured and predicted levels should not exceed ± 2 dB (see 5.3.2(b)).

C5.3.4.2 *CoRTN is known to predict noise levels to within 2 dB of the measured levels. Therefore, this is considered to be the appropriate degree of accuracy to apply to prediction methods.*

Any alternative prediction method utilised should achieve a similar degree of accuracy.

5.3.5 Noise model outputs

5.3.5.1 Diagrams of noise contours are visually useful for depicting noise exposure over the assessment area but include a degree of imprecision due to the interpolation between calculation points.

Specific predictions of noise levels for individual PPFs are more accurate, and shall be reported and form the basis of assessment.

5.3.5.2 Presentation of the results of noise predictions shall in all cases be accompanied by statements concerning the input variables, specifically items (a) to (i) listed in 5.3.3. The prediction model type and its basic description shall also be reported.

C5.3.5.2 *See section 9 for further reporting requirements.*

5.4 UNCERTAINTY

5.4.1 Prediction and measurement of sound levels from road traffic involves values of a range of parameters which can be known or predicted only within a certain tolerance. The sizes of such uncertainties determine the level of confidence in the overall results.

5.4.2 The uncertainty of sound levels as determined in this Standard depends on the traffic flow and road surface, the weather conditions, the measurement time interval, the distance from the source, barriers and effects on sound propagation, the measurement method, and instrumentation.

5.4.3 It is good practice to state the uncertainty and confidence level for all sound levels determined in accordance with this Standard. Uncertainty should be determined in accordance with the procedures in Craven and Kerry (2001).

5.4.4 The procedures specified in 5.4.3 involve determining the standard uncertainty for every source of uncertainty in the measurement/assessment process, and summing these standard uncertainties in quadrature (root sum of squares) to obtain the combined uncertainty. If a source of uncertainty is assumed to have a normal distribution, standard uncertainty is related to standard deviation, but this is not always the case and rectangular distributions are also common.

When comparing a sound level with the applicable noise criteria, the sound level should be deemed to comply if the sound level is equal to or less than the noise criteria. It should be deemed not to comply if the sound level is greater than the noise criteria regardless of the uncertainty. Where compliance or non-compliance is marginal and disputed, steps should be taken to reduce the uncertainty, where possible.

6 NOISE CRITERIA

6.1 CRITERIA

6.1.1 This section sets out the criteria for mitigating noise from new and altered roads at the assessment position(s) of PPFs. Sections 5, 6, 7, and 8, and Appendix C of this Standard explain how these criteria are to be applied in determining the best practicable option for mitigating road-traffic noise.

> ***C6.1.1*** *The criteria are reasonable taking into account adverse health effects associated with noise on people and communities, the effects of relative changes in noise levels, and the potential benefits of new and altered roads.*

6.1.2 The relevant criteria for noise from new and altered roads are set out in table 2 and shall apply at the assessment position(s) of PPFs for the design year as follows:

(a) Where consistent with the best practicable option for the mitigation of road-traffic noise, the criteria of Category A shall apply;

(b) Where it is inconsistent with the adoption of the best practicable option to achieve the criteria of Category A, the criteria of Category B shall apply;

(c) Where it is inconsistent with the adoption of the best practicable option to achieve the criteria of Category A or Category B and where the internal noise levels of any habitable space would be greater than 45 dB $L_{Aeq(24hr)}$, the criteria of Category C shall apply;

(d) Where it is inconsistent with the adoption of the best practicable option to achieve the criteria of Category A, B, or C, the internal noise levels of any habitable space shall be mitigated to the extent that it is practicable.

Table 2 – Noise criteria

Category	**Altered roads** dB $L_{Aeq(24h)}$	**New roads with a predicted traffic volume >75 000 AADT at the design year** dB $L_{Aeq(24h)}$	**New roads with a predicted traffic volume of 2000 to 75 000 AADT at the design year** dB $L_{Aeq(24h)}$
A (primary free-field external noise criterion)	64	64	57
B (secondary free-field external noise criterion)	67	67	64
C (internal noise criterion)	40	40	40

The calculation of internal noise levels shall be in accordance with 5.2.3.

> ***C6.1.2*** *Issues such as the practicability, technical feasibility, and/or affordability of implementing noise mitigation measures or the potential adverse effects of noise mitigation measures (such as, any potential for safety or visual effects) may mean that it is not consistent with the best practicable option to achieve full compliance with any of criteria A, B, or C at one or more assessment position in a particular case.*

6.2 SPECIAL CASES

6.2.1 In certain circumstances it may be more appropriate to apply one of the sets of criteria to some assessment positions affected by a project, and another set of criteria to other assessment positions affected by the same project.

Such circumstances may include, but are not limited to:

(a) An intersection between a new or altered road and an existing road;

(b) A 'tie-in', 'transition', or 'merger' where a new or altered road reconnects with an existing road; or

(c) Where any PPFs are significantly affected by noise from another existing road in the vicinity.

> ***C6.2.1*** *Appendix A provides an example of applying the noise criteria in table 2 to a special case (the creation of a new intersection between an existing road and a new road).*

6.2.2 Where PPFs are affected by noise from an existing road, mitigation is only required for road-traffic noise generated on the new or altered road.

6.3 BEST PRACTICE OPTION

NZS 6806 is intended to assist with the determination of the best practicable option for mitigating noise from new or altered roads.

The RMA defines best practicable option. When determining whether a noise mitigation option developed in accordance with 7.2 of this Standard represents the best practicable option, the following factors should be considered:

(a) The extent to which the mitigation option will achieve compliance with the relevant noise criteria in table 2;

(b) The extent to which structural mitigation measures will achieve the performance standards in 8.2.2;

(c) The extent to which the use of building modification measures would be required;

(d) Plan or policy statement noise management provisions;

(e) The value for money delivered by the mitigation option, including any ongoing maintenance costs associated with the option and consideration of benefit-cost analysis (see Appendix D for an example of an approach to calculating the benefit-cost ratio of noise mitigation options);

(f) The visual impact of the mitigation option;

(g) The consistency of the mitigation option with the New Zealand urban design protocol;

(h) The views of affected individuals and the known community views on the proposed mitigation option;

(i) The extent to which the mitigation option would comply with relevant safety Standards and guidelines;

(j) The technical feasibility of undertaking the mitigation option;

(k) The availability of sufficient land to implement and maintain the proposed mitigation measure(s) and the extent to which the road controlling authority/developer would need to acquire land, or interests in land, in order to carry out or maintain mitigation measures;

(l) Any potential effects of the noise mitigation option on public safety and security;

(m) Any other identified effects of the noise mitigation option on the environment (for example, effects on flora and fauna; effects on coastal processes, wetlands, lakes and rivers; effects on sites with known heritage, scientific, or cultural values; effects on public access to the coastal marine area, rivers, or lakes);

(n) Any other additional matters relevant to the particular new or altered road project under consideration.

7 DEVELOPMENT AND ASSESSMENT OF MITIGATION OPTIONS

7.1 USE OF PROFESSIONAL ACOUSTICIANS

Noise assessments in accordance with this Standard should be undertaken by suitably qualified and experienced persons.

7.2 NOISE ASSESSMENT AND DEVELOPMENT OF MITIGATION OPTIONS

7.2.1 The development and assessment of mitigation options necessary to achieve the noise criteria in section 6 shall be undertaken in accordance with this section. A diagrammatic representation of the process is shown as Appendix C.

7.2.2 Noise assessments shall be undertaken in accordance with the methodology set out in this Standard.

7.2.3 The development and testing of different mitigation options is necessary to show that the best practicable option has been used to mitigate noise to a reasonable level. The number of mitigation options that are to be assessed and the level of detail of the assessment of each mitigation option will depend upon the scale of the potential noise impact from the roading project.

7.2.4 The recommended number of mitigation options to be assessed is set out in table 3.

Table 3 – Recommended number of mitigation options to be assessed

Scale of noise impact	Example	No. of mitigation options
Small	Any new or altered road where there are fewer than 10 PPFs. For example: (a) Minor new roads in subdivisions; (b) Minor improvements at intersections.	Two
Medium	Any new or altered road where there are between 10 and 50 PPFs. For example: (a) Road widening to establish additional traffic lanes affecting urban areas; (b) Alterations to existing roads that may result in a significant increase in noise, such as works intended to significantly increase the design speed or traffic flow of an existing road or which would move traffic lanes closer to PPFs.	Three
Large	Any new or altered road where there are more than 50 PPFs. For example: (a) A new arterial road or state highway affecting urban areas; (b) Altered arterial roads or state highways affecting developed residential areas, such as a major intersection improvement or construction of elevated road structures or alterations, which would result in the road being re-categorised to a higher level in a district plan road hierarchy due to increased traffic flow.	Four

7.2.5 Noise assessment scenarios undertaken should be in accordance with table 4.

No specific noise mitigation is required under this Standard where Category A (from table 2) applies to all assessment positions at all PPFs and the do-minimum scenario (that is, the scenario without any measures being undertaken solely for the purpose of reducing noise) in table 4 applies.

Table 4 – Noise assessment scenarios

Assessment scenario	**Assessment year**	**Description**	**Category**	
			Altered road	**New road**
Existing noise environment	Current	Ambient sound levels at the assessment position(s) of PPFs at the date of assessment carried out under this Standard.	✓	✓
Do-nothing	Design year	The predicted noise levels at the assessment position(s) of PPFs at the design year assuming no alterations are made to the existing road.	✓	–
Do-minimum	Design year	The predicted noise levels at the assessment position(s) of PPFs at the design year with the project implemented including safety barriers and other structures (which may have an incidental noise mitigating effect). This assessment is not to include any measures undertaken for the sole purpose of reducing noise.	✓	✓
Mitigation Option 1	Design year	The predicted noise levels at the assessment position(s) of PPFs at the design year with the project implemented. Includes all measures with incidental noise mitigation as in the do-minimum scenario and a first option of specific noise mitigation measures which aim to achieve the relevant noise criteria in section 6.	✓	✓
Mitigation Options 2+	Design year	The predicted noise levels at the assessment position(s) of PPFs at the design year with the project implemented. Includes all measures with incidental noise mitigation as in the do-minimum scenario and a second option, in addition to mitigation option 1, of specific noise mitigation measures which aim to achieve the relevant noise criteria in section 6.	✓	✓

C7.2 Noise assessment and development of mitigation options

Although noise levels should be assessed for all assessment positions as outlined in table 4, this does not mean that noise levels need to be measured or modelled at all assessment positions. It may be possible in certain circumstances to undertake assessments using noise level data that is representative of several assessment positions.

Development of mitigation options is likely to be iterative. Further mitigation options should be assessed where necessary to arrive at a design for the best practicable option for mitigation. Appendix A provides examples of how mitigation options might be developed for different types of roading projects.

8 MITIGATION

8.1 INTRODUCTION

8.1.1 Where required to meet the criteria in section 6, noise mitigation measures shall be integrated into a roading project for a new or altered road early in the planning, design, and implementation stages of that project. See Appendix C for additional guidance.

8.1.2 In this Standard the preferred approach to noise control is to implement structural mitigation measures within the road reserve or near the new or altered road and only to consider building modification mitigation where it is not reasonable or feasible for structural mitigation to achieve the criteria in section 6.

8.1.3 Structural noise mitigation, including noise barriers, bunds, and building alterations, has significantly wider implications than noise mitigation. Advice and input from the relevant expertise as appropriate, such as planners, traffic engineers, structural engineers, urban designers, landscape architects, quantity surveyors, property managers, and archaeologists, should be obtained before mitigation options are developed.

8.2 STRUCTURAL MITIGATION

8.2.1 The preferred approach to noise control is to implement structural mitigation measures within the road reserve or within areas adjacent to, or in close proximity to, the new or altered road.

C8.2.1 *Structural mitigation should be implemented at or near the noise source for optimum effectiveness, for example by installing a low-noise road surface or road-side barriers.*

8.2.2 Where the need for noise mitigation measures has been identified, structural mitigation should only be implemented if the combination of the structural mitigation measures used would achieve the following:

(a) An average reduction of at least 3 dB $L_{Aeq(24h)}$ at the relevant assessment positions of all PPFs that are part of a cluster;

(b) A minimum reduction of 5 dB $L_{Aeq(24h)}$ at any assessment position(s) for each PPF that is not part of a cluster.

C8.2.2 *The requirements of 8.2.2 should be applied to only those PPFs that the structural mitigation is intended to benefit.*

8.2.3 The reduction in noise required in 8.2.2 should be determined by calculating the difference between the do-minimum noise environment and the noise environment, if the mitigation option including the structural mitigation, was implemented.

8.2.4 Where achieving 8.2.2(a) or 8.2.2(b) is inconsistent with the adoption of the best practicable option, then building modification mitigation shall be implemented in accordance with 6.1.2(c) or 6.1.2(d).

C8.2.4 *Structural mitigation includes:*

(a) Low-noise road surfaces – Different road surfaces have different noise characteristics associated with tyre-road interaction. 'Low-noise surfaces' have been used for many years and research and innovation is continuing as road surface decisions also need to consider safety, longevity, wear, and cost;

(b) Noise barriers – Barriers work by interrupting the 'acoustic line-of-sight'/transmission of noise along the propagation path between the source and receiver. Barriers generally need specific design to provide the required mitigation and can have other effects such as safety or visual.

8.2.5 Structural mitigation measures should be designed in such a way that they retain the same noise-reduction properties up to the design year.

C8.2.5 *For example, a noise barrier that is intended to achieve a 3 dB* $L_{Aeq(24h)}$ *noise reduction at a certain point should be designed so that it continues to have 3 dB* $L_{Aeq(24h)}$ *noise reduction at that point up to the design year. Other factors (such as new development in the area) may mean that overall the noise received at that point rises over the period leading up to the design year.*

8.3 BUILDING MODIFICATION MITIGATION

8.3.1 Building modification mitigation measures should only be considered as a means of mitigating the noise effects of any new or altered road where it is not reasonable or feasible for structural mitigation measures to achieve the noise criteria in section 6.

8.3.2 Building modification mitigation may involve altering existing buildings so that the degree of acoustic insulation offered by the building envelope increases. This provides an effective way of reducing indoor noise levels in habitable spaces. However, adequate ventilation should be provided and improving acoustic insulation does not reduce noise in outdoor areas.

8.3.3 Any building modification for the purpose of noise mitigation shall be designed to meet the criteria in table 2 and NZBC Clause G4.

8.3.4 Building-modification mitigation shall only be implemented subsequent to the achievement of the lowest practicable external noise levels.

8.4 CIRCUMSTANCES NOT REQUIRING MITIGATION

Structural or building modification mitigation measures are not required where:

(a) The noise is predicted to meet Category A (the relevant primary external noise criterion) set out in table 2 at all assessment position(s) at all PPFs at the design year without any specific noise mitigation being undertaken; or

(b) The consent of any landowner or occupier to carry out mitigation measures on their land cannot be obtained; and the following apply:

  (i) The land on which the road controlling authority or developer is seeking to carry out noise mitigation measures is not subject to a designation for roading purposes

  (ii) The road controlling authority or developer cannot obtain the consent of the landowner or any occupier to purchase the land, or an interest in the land, required for the noise mitigation works to be carried out on that land at market value, and

  (iii) It is unreasonable or unfeasible to achieve the noise criteria in section 6 without undertaking mitigation measures on that land.

C8.4 *In the circumstances set out in 8.4(b), there will be no obligation on the road controlling authority or developer to meet the criteria in section 6 for those PPFs which would have had the benefit of the noise mitigation measures that the road controlling authority/developer sought to undertake on that land.*

9 INFORMATION TO BE INCLUDED IN REPORTS

9.1 INTRODUCTION

In addition to information required by NZS 6801, and if relevant NZS 6802, the following matters should be included in any report required by this Standard:

9.1.1 General

The following general information should be provided:

(a) Name of person(s) responsible for carrying out the measurements, predictions, and assessment;

(b) A statement that the sound measurements and records comply with the requirements of NZS 6801, and assessments have been made in accordance with this Standard, or if some deviation has been necessary, then full details of the deviation;

(c) The design year;

(d) Description of the noise model and the model input variables used (see 5.3.5.2);

(e) Results including any field tests made to check whether predicted noise levels vary from the measured levels (see 5.3.4.2); and

(f) The date of the assessment.

9.1.2 Landform and development

The following landform and development information should be provided:

(a) Terrain data including ground contour interval (see 5.3.3(g));

(b) Road layout, edge of carriageway, number of traffic lanes, and location of all types of intersections including road mergers;

(c) Locations where PPFs are affected by noise from an existing road (see 6.2.2);

(d) Location of barriers and buildings (see 5.3.3 (h)); and

(e) Assessment positions for affected PPFs.

9.1.3 Assessment factors

The following information should also be provided:

(a) The number of mitigation options assessed and the level of detail of the assessment (see 7.2);

(b) A noise assessment scenario matrix for each assessment undertaken (see table 4);

(c) Details of any further mitigation options considered (see C7.2);

(d) Details of any structural mitigation (see 8.2);

(e) Details of the design performance to be achieved by structural mitigation measures (see 8.2.4);

(f) Details sufficient to demonstrate that building modification mitigation can achieve concurrent compliance with the acoustic and ventilation requirements of section 8.3;

(g) Details of any circumstances not requiring mitigation (see 8.4); and

(h) Details of noise management measures including distance attenuation, ground absorption, shielding, topography, road surface, building orientation, isolation, and relocation (see 8.3).

C9.1 *A report should be objective and impartial. The report should attempt to describe the existing and predicted sound environment at the time of assessment and in particular what sources are controlling road-traffic noise key descriptors. Variation in predicted or measured sound levels should be reported.*

The report should explain fully the justification for selecting mitigation measures or design criteria to a degree that will satisfy an audit against the criteria and recommended practices in this Standard.

Publication of summaries and brochures designed for lay readers is encouraged to supplement formal reporting in accordance with the requirements of this section.

9.2 TRAFFIC VOLUME AND CRITERIA

A report shall be prepared to explain the following:

(a) Which parts of the project (if any) were treated as altered roads or new roads with a predicted traffic volume of > 75 000 AADT;

(b) Which parts of the project (if any) were treated as new roads with a predicted traffic volume of 2000 to 75 000 AADT; and

(c) Whether the criteria in Category A, B, or C for each assessment position at PPFs are predicted to be met following implementation of the chosen noise mitigation method.

APPENDIX A – NOISE MITIGATION AND ASSESSMENT EXAMPLES

(Informative)

A1 INTRODUCTION

A1.1 This appendix provides examples of applying the noise mitigation and assessment process set out in this Standard.

The following worked examples have been provided:

Example	Description	Clause
1 – Altered road	Alteration of an existing road in an urban environment involving the provision of an additional traffic lane	A2
2 – New road	Development of a new road in a rural 'greenfield' environment	A3
3 – Special case	Development of a new intersection to connect a new road and an existing road in a rural environment	A4
4 – Altered road	Alteration of an existing road in an urban environment involving the replacement of a roundabout with a signalised intersection	A5

A1.2 In these examples all noise level predictions are undertaken in accordance with the UK Department of Transport and Welsh Office CoRTN method, adjusted to New Zealand conditions in accordance with Land Transport New Zealand *research report 326*. The resulting $L_{A10(18h)}$ free-field level is converted into a $L_{Aeq(24h)}$ free-field level by subtracting 3 dB (refer to Fwa 2006).

A2 EXAMPLE 1 – ALTERED ROAD – ALTERATION OF AN EXISTING ROAD IN AN URBAN ENVIRONMENT INVOLVING THE PROVISION OF AN ADDITIONAL TRAFFIC LANE

A2.1 Existing

Current road layout at date of assessment

Determine the existing noise environment using the following process:

(a) Undertake screening assessment to determine application of this Standard (see 1.3.1(d));

(b) As the roading project is in an urban environment (see 2.2), identify all PPFs within 100 m of the edge of the closest altered traffic lane. (In this example the PPFs are all single-storey residential dwellings with one assessment position each, and are labelled A – I in figure A1);

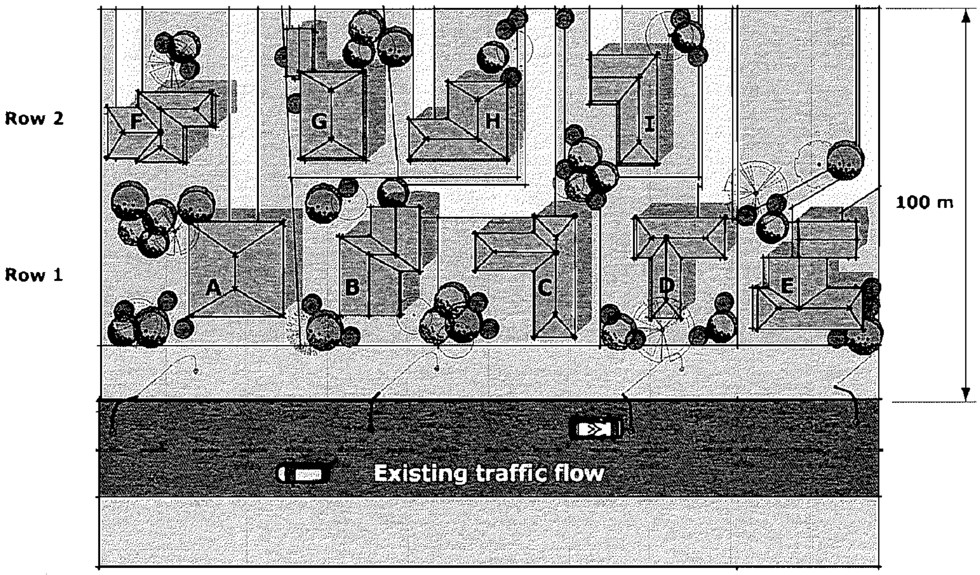
(c) Measure existing ambient sound levels at assessment position(s) representative of the PPFs shown in figure A1;

(d) Determine the existing noise environment at the assessment positions of all PPFs using the measurements taken and/or calibrated noise model predictions (see section 5).

Table A1 provides the assessment details of the existing noise environment for example 1. Table A2 provides the results of the existing noise environment assessment. Figure A1 provides a schematic representation of the scenario being assessed.

Table A1 – Example 1 – Step A2.1 Assessment details – Existing – Current road layout at date of assessment

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
AADT (existing year)	25,000 vpd	vpd refers to vehicles per day
Average vehicle speed	80 km/h	–
Heavy commercial vehicles (HCV)	10%	–
Road surface material	Chip seal	–



Urban environment

Figure A1 – Example 1 – Step A2.1 – Schematic representation – Existing – Current road layout at date of assessment

Table A2 – Example 1 – Step A2.1 Results – Existing – Current road layout at date of assessment

PPF	**Existing** **External noise level** (dB $L_{Aeq(24h)}$)
A	76
B	75
C	74
D	73
E	74
F	56
G	57
H	56
I	55

NOTE – The existing or 'baseline' noise levels include noise from all existing local roads and state highways in their existing condition. Baseline noise levels also include noise from industry as well as other noise sources that are situated near to the location of the roading project.

A2.2 Do-nothing

Current road layout at design year

Determine the do-nothing noise environment using the following process:

(a) Determine the design year (see 2.2) of the roading project;

(b) Using an appropriate noise model (see 5.3.2 and A1.2) predict noise levels for the design year taking into account the future traffic flow (AADT), and assuming no alterations are made to the existing road layout;

(c) Ensure predictions are made for the assessment positions of all PPFs identified in step A2.2(b).

Table A3 provides the do-nothing noise environment assessment details for example 1. Table A4 provides the results of the existing noise environment assessment. Figure A2 provides a schematic representation of scenario being assessed.

Table A3 – Example 1 – Step A2.2 Assessment details – Do-nothing – Current road layout at design year

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
AADT (existing year)	30,000 vpd	Increase from existing year due to natural growth in traffic
Average vehicle speed	80 km/h	–
Heavy commercial vehicles (HCV)	10%	–
Road surface material	Chip seal	–

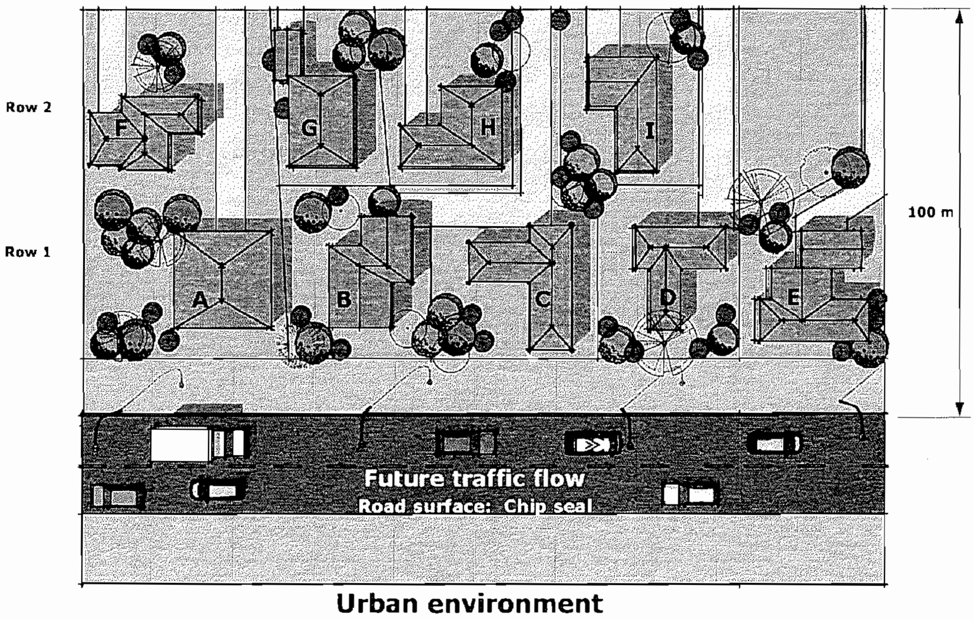


Figure A2 – Example 1 – Step A2.2 – Schematic representation – Do-nothing – Current road layout at design year

Table A4 – Example 1 – Step A2.2 Results – Do-nothing – Current road layout at design year

PPF	Existing	Do-nothing
	External noise level (dB $L_{Aeq(24h)}$)	
A	76	77
B	75	76
C	74	75
D	73	74
E	74	75
F	56	57
G	57	58
H	56	57
I	55	56

CA2.2 *The predicted design year do-nothing noise levels assume all existing local roads and state highways are in their current location and condition. Depending on circumstances this may mean an increase or decrease of traffic volumes due to other roading projects and developments in the vicinity. Predictions of future traffic flows should comply with the requirements of 1.2.3.*

A2.3 Do-minimum

Future road layout at design year without specific noise mitigation

Determine the do-minimum noise environment using the following process:

(a) Using an appropriate noise model (see 5.3.2 and A1.2) predict noise levels at the design year with the roading project implemented taking into account the future traffic flow (AADT), and including safety barriers and/or other structures which may have incidental noise mitigating effects. In this example solid safety 'New Jersey' barriers are predicted to provide incidental noise mitigation (see also CA2.3);

(b) Ensure predictions are made for the assessment positions of all PPFs identified in step A2.1(b);

(c) Review the existing noise environment and compare the predictions for the do-minimum noise environment with those for the do-nothing environment to confirm the findings from step A2.1(a) that the roading project is an altered road as defined in this Standard (see 1.5.2 and CA2.4);

(d) Identify the relevant noise criteria from table 2 for an altered road.

Table A5 provides the do-minimum noise environment assessment details for example 1. Table A6 provides the results of the do-minimum noise environment assessment. Figure A3 provides a schematic representation of scenario being assessed.

Table A5 – Example 1 – Step A2.3 Assessment details – Do-minimum – Future road layout at design year without specific noise mitigation

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
AADT (existing year)	35,000 vpd	Increase from existing year due to alterations and natural growth in traffic
Average vehicle speed	100 km/h	Increase due to alterations
Heavy commercial vehicles (HCV)	10%	–
Road surface material	Chip seal	–
Altered road layout	Additional lane	Additional traffic lane to be constructed on side adjacent to PPFs. Solid concrete 'New Jersey' safety barriers installed as part of the alterations

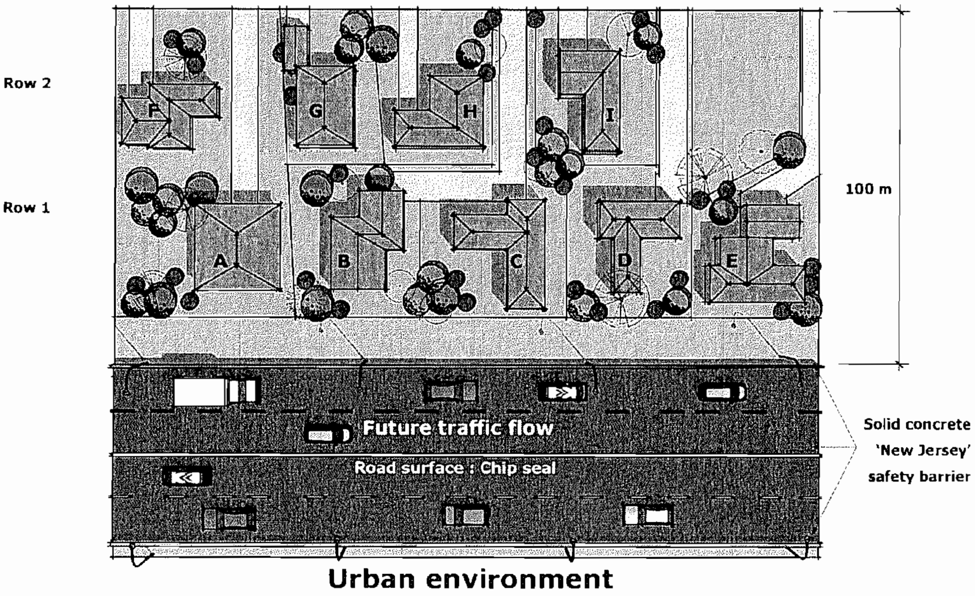


Figure A3 – Example 1 – Step A2.3 – Schematic representation – Do-minimum – Future road layout at design year without specific noise mitigation

Table A6 – Example 1 – Step A2.3 Results – Do-minimum – Future road layout at design year without specific noise mitigation

PPF	**Existing**	**Do-nothing**	**Do-minimum**	**Altered road**		
	External noise level (dB $L_{Aeq(24h)}$)			**Threshold exceeded** (see 1.5.2)	**Noise criteria**	
					Category A	**Category B**
A	76	77	79	Y	64	67
B	75	76	79	Y	64	67
C	74	75	76	Y	64	67
D	73	74	75	Y	64	67
E	74	75	78	Y	64	67
F	56	57	59	N	64	67
G	57	58	60	N	64	67
H	56	57	59	N	64	67
I	55	56	58	N	64	67

CA2.3 *No measures specifically designed for noise mitigation should be included in the predictions of the do-minimum noise environment.*

If the do-minimum noise levels predicted for all PPFs are less than the altered road Category A criterion (64 dB $L_{Aeq(24h)}$) from table 2 then no specific noise mitigation measures would be required.

A2.4 Mitigation option 1

Future road layout at design year with noise mitigation

Determine the assessment details for mitigation option 1 using the following process:

(a) Determine the number of mitigation options to be developed using table 3 (see also CA2.4);

(b) Using an appropriate noise model (see 5.3.2 and A1.2) predict noise levels at the design year with the roading project implemented taking into account the predicted traffic flow (AADT), and including solid concrete 'New Jersey' safety barriers predicted to provide incidental noise mitigation in step A2.3, and a first option of noise mitigation measures as shown in table A7;

(c) Ensure predictions are made for the assessment positions of all PPFs identified in step A2.1(b);

(d) Identify which PPFs are parts of a cluster as defined in 2.2. (In this example, the assessment positions of all PPFs labelled A – I in figure A4 are within 100 m of each other and are also on the same side of the altered road. These PPFs form a single cluster);

(e) Examine whether or not structural mitigation implemented in this mitigation option will achieve the performance standards specified in 8.2.2;

(f) Determine whether or not any PPFs require building modification mitigation.

Table A7 provides the mitigation option 1 assessment details for example 1. Table A8 provides the mitigation option 1 results for example 1. Figure A4 provides a schematic representation of scenario being assessed.

Table A7 – Example 1 – Step A2.4 Assessment details – Mitigation option 1 – Future road layout at design year with noise mitigation

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
AADT (design year)	35,000 vpd	Increase from existing year due to alterations and natural growth in traffic
Average vehicle speed	100 km/h	Increase due to alterations
Heavy commercial vehicles (HCV)	10%	–
Road surface material	AC	Asphaltic concrete (AC) installed specifically as structural noise mitigation
Altered road layout	Additional lane	Additional traffic lane to be constructed on side adjacent to PPFs. Solid concrete 'New Jersey' safety barriers installed as part of the alterations
Mitigation option 1	Road surface and barriers	AC low-noise surface and 2 m (high) by 210 m (long) noise barrier as shown in figure A4
Clusters	1	PPFs A – I in figure A4 form one cluster

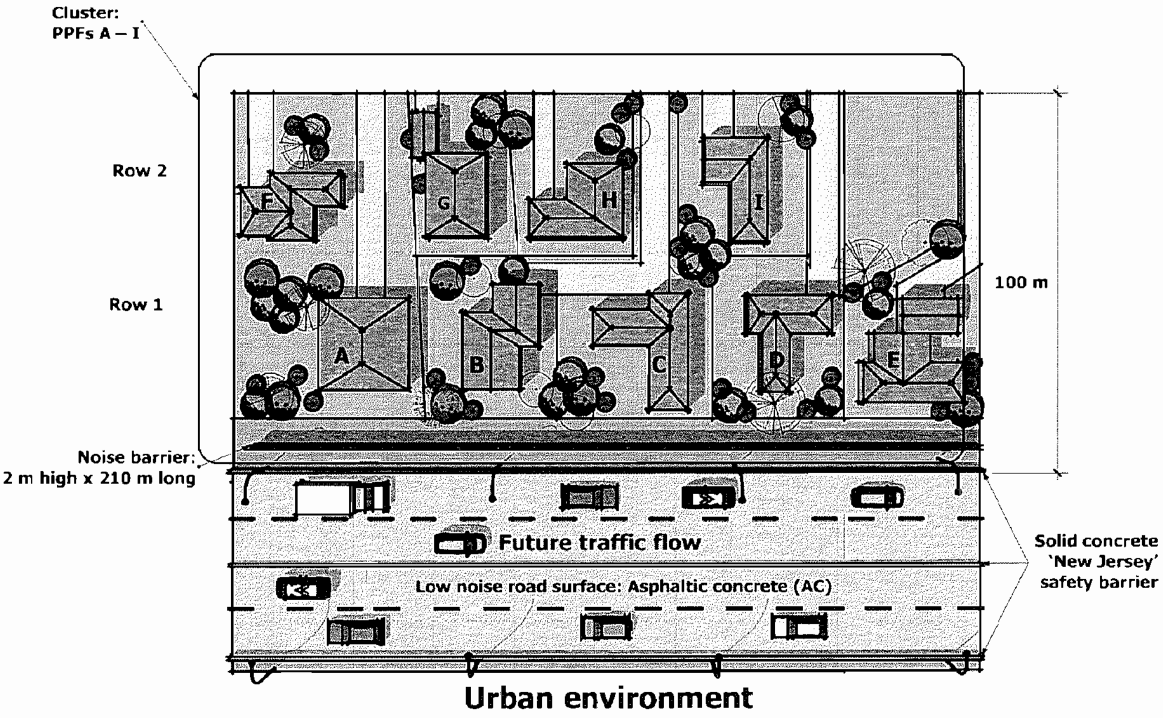


Figure A4 – Example 1 – Step A2.4 – Schematic representation – Mitigation option 1 – Future road layout at design year with noise mitigation

Table A8 – Example 1 – Step A2.4 Results – Mitigation option 1 – Future road layout at design year with noise mitigation

PPF	Existing	Do-nothing	Do-minimum	Mitigation option 1	Altered road				Structural mitigation performance (see 8.2.2)		Building modification mitigation required?
	External noise level (dB $L_{Aeq(24h)}$)				Category A		Category B		Individual PPF	Individual PPF compliance?	
					Criteria	Option 1 applies?	Criteria	Option 1 applies?	dB $L_{Aeq(24h)}$		
A	76	77	79	64	64	Y	67	Y	15	Not applicable	N
B	75	76	79	64	64	Y	67	Y	15	Not applicable	N
C	74	75	76	63	64	Y	67	Y	13	Not applicable	N
D	73	74	75	62	64	Y	67	Y	13	Not applicable	N
E	74	75	78	63	64	Y	67	Y	15	Not applicable	N
F	56	57	59	48	64	Y	67	Y	11	Not applicable	N
G	57	58	60	50	64	Y	67	Y	10	Not applicable	N
H	56	57	59	49	64	Y	67	Y	10	Not applicable	N
I	55	56	58	48	64	Y	67	Y	10	Not applicable	N
								Cluster average	12		
								Cluster compliance	Y		

CA2.4 *Since one or more of the thresholds specified in 1.5.2 are exceeded at one or more relevant PPF, the roading project is an altered road as defined in 1.5. The Standard should therefore be applied to all PPFs identified in step A2.1(b). As there are fewer than ten PPFs, at least two mitigation options should be developed (see table 3).*

Structural mitigation performance specified in 8.2.2(b) does not apply to PPFs that are part of a cluster.

A2.5 Mitigation option 2

Future road layout at design year with noise mitigation

Determine the assessment details for mitigation option 2 using the following process:

(a) Using an appropriate noise model (see 5.3.2 and A1.2) predict noise levels at the design year with the roading project implemented taking into account the predicted traffic flow, and including solid concrete 'New Jersey' safety barriers predicted to provide incidental noise mitigation in step A2.3, and a second option of noise mitigation measures as shown in table A9;

(b) Ensure predictions are made for the assessment positions of all PPFs identified in step A2.1(b);

(c) Examine whether or not structural mitigation implemented in this mitigation option will achieve the performance standards specified in 8.2.2;

(d) Determine whether or not any PPFs require building modification mitigation. (In this example PPFs A and B will require acoustic insulation as shown in figure A5.)

Table A9 provides the mitigation option 2 assessment details for example 1. Table A10 provides the mitigation option 2 results for example 1. Figure A5 provides a schematic representation of scenario being assessed.

Table A9 – Example 1 – Step A2.5 Assessment details – Mitigation option 2 – Future road layout at design year with noise mitigation

Parameter	**Detail**	**Notes**
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
AADT (design year)	35,000 vpd	Increase from existing year due to alterations and natural growth in traffic
Average vehicle speed	100 km/h	Increase due to alterations
Heavy commercial vehicles (HCV)	10%	–
Road surface material	Chip seal	Asphaltic concrete (AC) installed specifically as structural noise mitigation
Altered road layout	Additional lane	Additional traffic lane to be constructed on side adjacent to PPFs. Solid concrete 'New Jersey' safety barriers installed as part of the alterations
Mitigation option 2	Barriers and insulation	1.8 m (high) by 195 m (long) noise barrier as shown in figure A5 and acoustic insulation for PPFs A and B
Clusters	1	PPFs A – I in figure A5 form one cluster

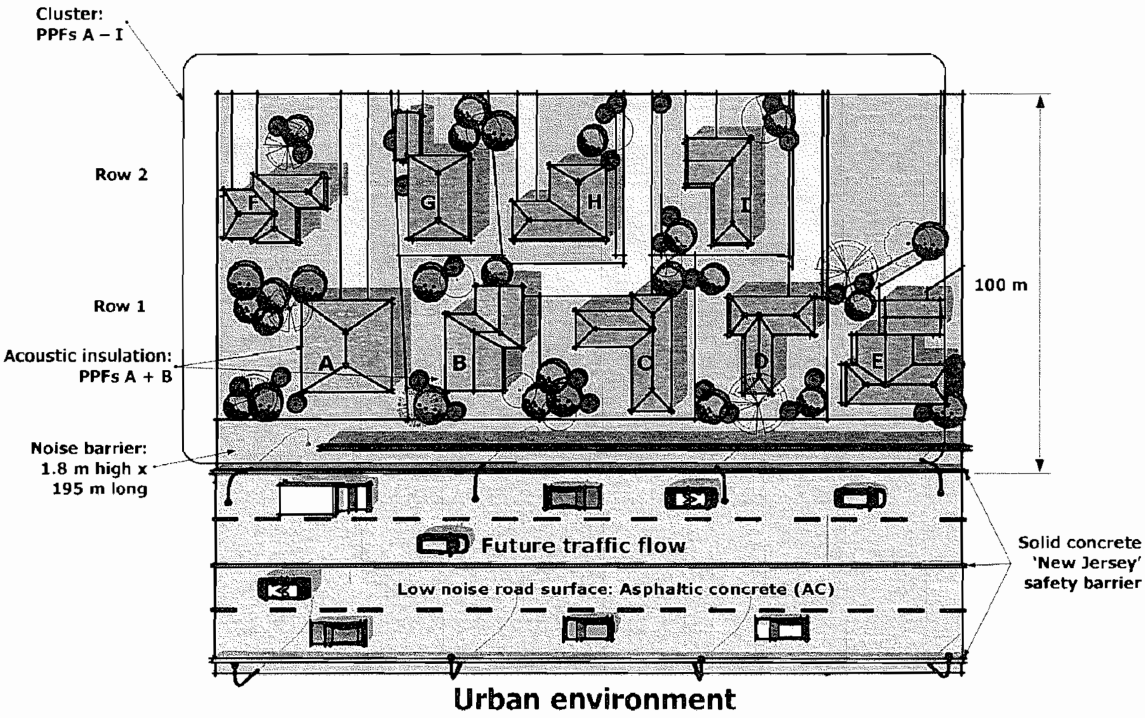


Figure A5 – Example 1 – Step A2.5 – Schematic representation – Mitigation option 2 – Future road layout at design year with noise mitigation

Table A10 – Example 1 – Step A2.5 Results – Mitigation option 2 – Future road layout at design year with noise mitigation

PPF	Existing	Do-nothing	Do-minimum	Mitigation option 2	Altered road				Structural mitigation performance (see 8.2.2)		Building modification mitigation required?
	External noise level (dB $L_{Aeq(24h)}$)				Category A		Category B		Individual PPF	Individual PPF compliance?	
					Criteria	Option 2 complies?	Criteria	Option 2 complies?	dB $L_{Aeq(24h)}$		
A	76	77	79	69	64	N	67	N	10	Not applicable	Y
B	75	76	79	68	64	N	67	N	11	Not applicable	Y
C	74	75	76	67	64	N	67	Y	9	Not applicable	N
D	73	74	75	66	64	N	67	Y	9	Not applicable	N
E	74	75	78	67	64	N	67	Y	11	Not applicable	N
F	56	57	59	52	64	Y	67	Y	7	Not applicable	N
G	57	58	60	54	64	Y	67	Y	6	Not applicable	N
H	56	57	59	53	64	Y	67	Y	6	Not applicable	N
I	55	56	58	52	64	Y	67	Y	6	Not applicable	N
								Cluster average	8		
								Cluster compliance	Y		

A2.6 Comparison of mitigation options

Using the information from tables A8 and A10 compare the relative effectiveness and merits of each mitigation option with a view to determining the best practicable option. The two mitigation options are described in table A11 and are compared in table A12.

Table A11 – Example 1 – Mitigation option details

Option number	Detail	Notes
1	Road surface and barriers	AC low-noise road surface and 2 m (high) by 210 m (long) noise barrier as shown in figure A4
2	Barriers and insulation	1.8 m (high) by 195 m (long) noise barrier as shown in figure A5 and acoustic insulation for PPFs A and B

Table A12 – Example 1 – Comparison of mitigation options

<table>
<tr><th>Detail</th><th>Mitigation option 1</th><th>Mitigation option 2</th></tr>
<tr><td rowspan="2">Structural mitigation</td><td colspan="2">Noise barrier</td></tr>
<tr><td>2 m (high) by 210 m (long)</td><td>1.8 m (high) by 195 m (long)</td></tr>
<tr><td rowspan="3">Road surface material</td><td colspan="2">Low-noise road surface</td></tr>
<tr><td>AC</td><td>Not applicable</td></tr>
<tr><td>AC</td><td>Chip seal</td></tr>
<tr><td>Building modification mitigation</td><td>Number of PPFs = 0</td><td>Number of PPFs = 2</td></tr>
<tr><td rowspan="2">Altered road noise criteria compliance</td><td>Category A = 100% (9 of 9)</td><td>Category A = 44% (4 of 9)</td></tr>
<tr><td>Category B = 100% (9 of 9)</td><td>Category B = 78% (7 of 9)</td></tr>
<tr><td rowspan="2">Structural mitigation performance compliance</td><td>Clusters = 100% (1 of 1)</td><td>Clusters = 100% (1 of 1)</td></tr>
<tr><td>Individual PPFs = not applicable</td><td>Individual PPFs = not applicable</td></tr>
<tr><td>Rank by preference</td><td>1</td><td>2</td></tr>
</table>

CA2.6 *A benefit-cost analysis could also be undertaken of each noise mitigation option using the methodology provided in Appendix D. This analysis would provide additional information to assist the decision-making process identifying the best practicable option.*

A2.7 Discussion

From a noise management perspective, mitigation option 1 is preferred to option 2. Compared to option 2, option 1 involves the provision of a slightly longer and higher noise barrier and makes use of asphaltic concrete rather than chip seal. This combination of structural mitigation achieves compliance with the Category A noise criterion for altered roads at all PPFs. In addition, it has greater benefits for outdoor living areas. By contrast, option 2 only achieves 44% compliance with this criterion.

In option 1, noise levels at all PPFs comply with the Category A criterion. As a result there is no need for building modification mitigation such as acoustic insulation. For option 2, the choice of structural mitigation does not achieve compliance with the Category B noise criterion at two PPFs. As the internal noise level for these two dwellings is predicted to be above 45 dB $L_{Aeq(24h)}$, building modification mitigation measures in the form of acoustic insulation would need to be offered to these PPFs.

The development of mitigation options is an iterative process. It is therefore essential that there is early and ongoing dialogue between the acoustician(s) responsible for the noise assessment and specialists from other disciplines, such as traffic engineers, urban designers, planners, property managers, archaeologists, and quantity surveyors. These specialists might raise issues such as access, safety, visual appearance, cost, or effects on historic places that also need to be taken into account. As a result, mitigation option 2 or a modified version of mitigation option 1 might represent the best practicable option, for example if the current mitigation option 1 gives rise to unacceptable safety risks such as restricted traffic sight lines associated with the proposed noise barrier.

A3 EXAMPLE 2 – NEW ROAD
DEVELOPMENT OF A NEW ROAD IN A RURAL 'GREENFIELD' ENVIRONMENT

A3.1 Existing noise environment

Greenfield situation at date of assessment

Determine the existing noise environment using the following process:

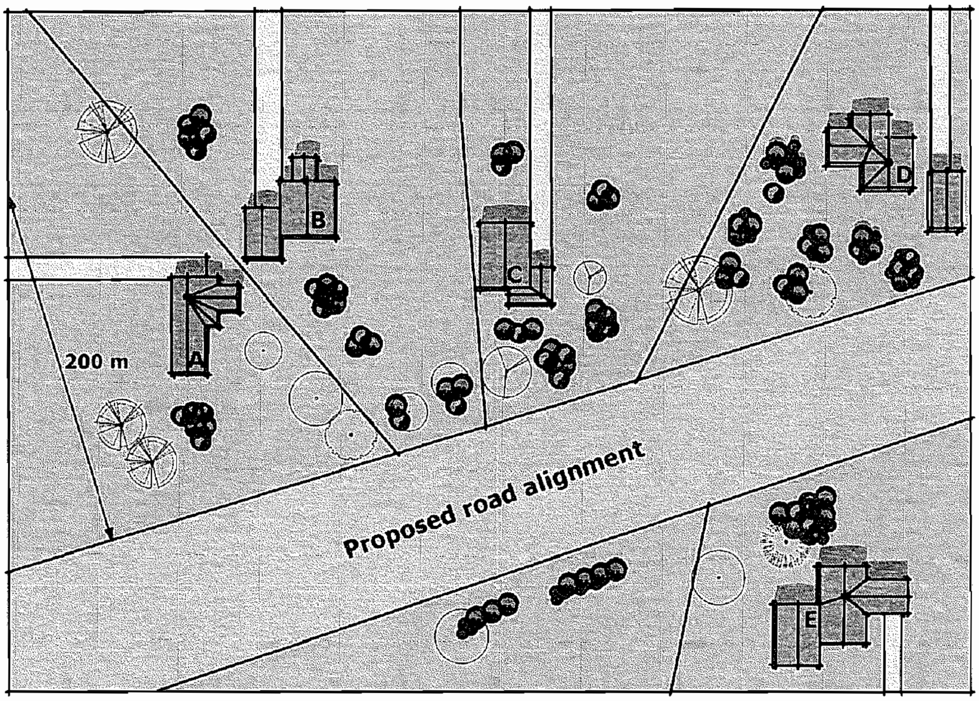
(a) Undertake screening assessment to determine application of this Standard (see 1.3.1(d));

(b) As the roading project is in a rural environment, identify all PPFs within 200 m of the edge of the closest new traffic lane (see 1.4.2). (In this example the PPFs are all single-storey residential dwellings with one assessment position each, and are labelled A – E in figure A6);

(c) Measure existing ambient sound levels at assessment position(s) representative of the PPFs shown in figure A6;

(d) Determine the existing noise environment at the assessment positions of all PPFs using the measurements taken (see section 5).

Table A13 provides the results of the existing noise environment assessment. Figure A6 provides a schematic representation of scenario being assessed.



Rural environment

Figure A6 – Example 2 – Step A3.1 – Schematic representation – Existing noise environment – Greenfield situation at date of assessment

Table A13 – Example 2 – Step A3.1 Results – Existing noise environment – Greenfield situation at date of assessment

PPF	Existing External noise level (dB $L_{Aeq(24h)}$)
A	43
B	42
C	43
D	41
E	46
NOTE – The existing or 'baseline' noise levels include noise from all existing local roads and state highways in their existing condition. Baseline levels also include noise from other noise sources that are situated near to the location of the roading project.	

CA3.1 *As no road currently exists, it is not possible to use road noise model predictions to determine the existing noise environment.*

A3.2 Do-minimum noise environment

New road layout at design year without specific noise mitigation

Determine the do-minimum noise environment using the following process:

(a) Determine the design year (see 2.2) of the roading project;

(b) Using an appropriate noise model (see 5.3.2 and A1.2) predict noise levels from the new road for the design year taking into account the predicted traffic flow (AADT), and including safety barriers and/or other structures which may have an incidental noise mitigating effects. In this example solid safety 'New Jersey' barriers are predicted to provide incidental noise mitigation (see CA3.2);

(c) Ensure predictions are made for the assessment positions of all PPFs;

(d) Ensure any noise model predictions are calibrated (see 5.3.4 and CA3.2);

(e) Review the existing noise environment and compare the predictions with the existing noise environment to confirm that the roading project is a new road as defined in this Standard (see 1.6);

(f) Identify the relevant noise criteria from table 2 for a new road. Since the predicted AADT for the new road is 40,000 vpd in this example, the relevant criteria is that for new roads with an AADT of less than 75,000 vpd.

Table A14 provides the do-minimum noise environment assessment details for example 2. Table A15 provides the results of the do-minimum noise environment assessment. Figure A7 provides a schematic representation of scenario being assessed.

Table A14 – Example 2 – Step A3.2 Assessment details – Do-minimum noise environment – New road layout at design year without specific noise mitigation

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
AADT (design year)	40,000 vpd	–
Average vehicle speed	100 km/h	–
Heavy commercial vehicles (HCV)	12%	–
Road surface material	Chip seal	–
Altered road layout	New road	New road to be constructed in a 'greenfield' rural environment. Solid concrete 'New Jersey' safety barriers installed as part of new road layout
Mitigation option 2	Barriers and insulation	1.8 m (high) by 195 m (long) noise barrier as shown in figure A7 and acoustic insulation for PPFs A and B
Clusters	1	PPFs A – I in figure A5 form one cluster

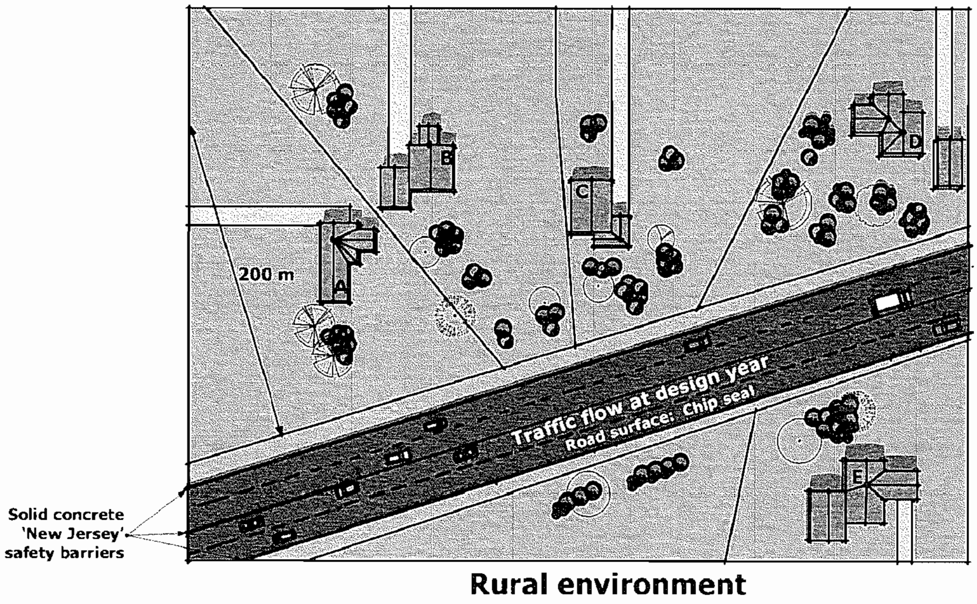

200 m
A
B
C
D
E
Traffic flow at design year
Road surface: Chip seal
Solid concrete 'New Jersey' safety barriers
Rural environment

Figure A7 – Example 2 – Step A3.2 – Schematic representation – Do-minimum noise environment – New road layout at design year without specific noise mitigation

Table A15 – Example 2 – Step A3.2 Results – Do-minimum noise environment – New road layout at design year without specific noise mitigation

PPF	Existing	Do-minimum	Altered road		
	External noise level (dB $L_{Aeq(24h)}$)		Threshold exceeded (see 1.6)	Noise criteria	
				Category A	Category B
A	76	79	Y	57	64
B	75	79	Y	57	64
C	74	76	Y	57	64
D	73	75	Y	57	64
E	74	78	Y	57	64

NOTE – Since the threshold specified in 1.6 is exceeded at one or more PPF and the roading project meets the definition of a new road, the Standard should be applied to all PPFs identified in step A3.1(b) above. Since there are fewer than ten PPFs at least two mitigation options should be developed (see table 3).

CA3.2 *No measures specifically designed for noise mitigation should be included in the predictions of the do-minimum noise environment.*

Calibrating a noise model for a new road can only be done for locations where existing noise environment measurements are taken in the vicinity of the merge or tie-in between the new road and an existing road. That is, where it is necessary to include predictions of existing road noise in the model.

If the do-minimum noise levels predicted for all PPFs are less than the relevant new road Category A criterion from table 2 then no specific noise mitigation measures would be required.

A3.3 Mitigation option 1

New road layout at design year with noise mitigation

Determine the assessment details for mitigation option 1 using the following:

(a) Using an appropriate noise model (see 5.3.2 and A1.2) predict noise levels from the new road at the design year taking into account the predicted traffic flow (AADT), and including solid concrete 'New Jersey' safety barriers predicted to provide incidental noise mitigation in step A2.3, and a first option of noise mitigation measures as shown in table A16;

(b) Ensure predictions are made for the assessment positions of all PPFs;

(c) Identify which PPFs are parts of a cluster as defined in section 2.2. In this example the assessment positions of the PPFs labelled A – C in figure A8 are within 100 m of each other and also on the same side of the road. These form a single cluster. PPFs D and E are not part of a cluster;

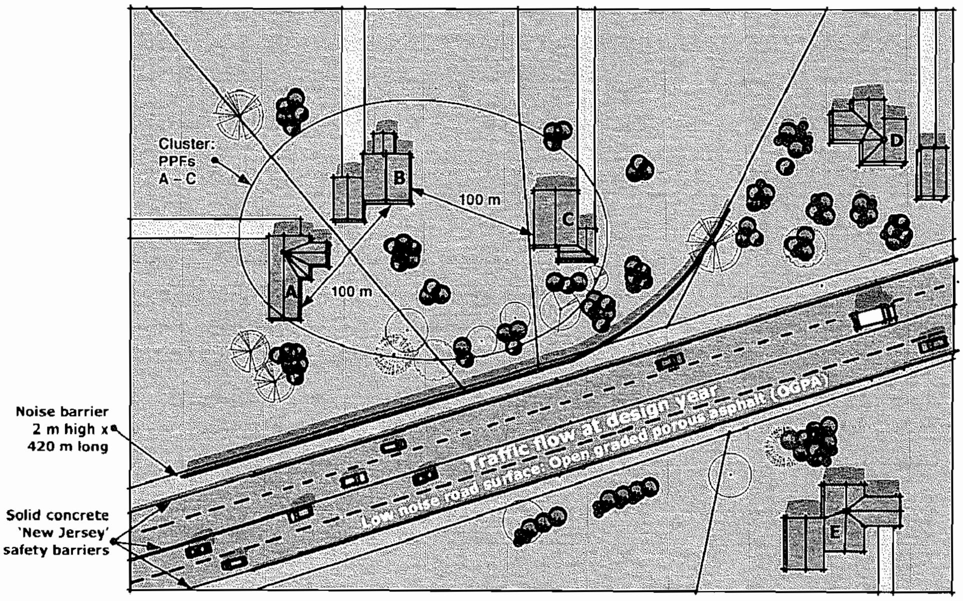
(d) Examine whether or not structural mitigation implemented in this mitigation option will achieve the performance standards specified in 8.2.2;

(e) Determine whether or not any PPFs require building modification mitigation.

Table A16 provides the mitigation option 1 assessment details for example 2. Table A17 provides the mitigation option 1 results for example 2. Figure A8 provides a schematic representation of scenario being assessed.

Table A16 – Example 2 – Step A3.3 Assessment details – Mitigation option 1 – New road layout at design year with noise mitigation

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
AADT (design year)	40,000 vpd	–
Average vehicle speed	100 km/h	–
Heavy commercial vehicles (HCV)	12%	–
Road surface material	OGPA	Open graded porous asphalt (OGPA) has been specifically installed as structural noise mitigation
New road	New road	New road to be constructed in a 'greenfield' rural environment. Solid concrete 'New Jersey' safety barriers installed as part of new road layout
Mitigation option 1	Road surface and barriers	OGPA low-noise road surface and 2 m (high) by 420 m (long) noise barrier installed as part of new road layout
Clusters	1	PPFs A – C in figure A8 form one cluster. PPFs D and E are not part of a cluster



Rural environment

Figure A8 – Example 2 – Step A3.3 – Schematic representation – Mitigation option 1 – New road layout at design year with noise mitigation

Table A17 – Example 2 – Step A3.3 Results – Mitigation option 1 – New road layout at design year with noise mitigation

PPF	Existing	Do-minimum	Mitigation option 1	Altered road				Structural mitigation performance (see 8.2.2)		Building modification mitigation required?
	External noise level (dB $L_{Aeq(24h)}$)			Category A		Category B		Individual PPF	Individual PPF compliance?	
				Criteria	Option 1 complies?	Criteria	Option 1 complies?	dB $L_{Aeq(24h)}$		
A	43	61	50	57	Y	64	Y	11	Not applicable	N
B	42	62	51	57	Y	64	Y	11	Not applicable	N
C	43	62	55	57	Y	64	Y	7	Not applicable	N
D	41	63	59	57	N	64	Y	4	No	N
E	46	66	56	57	Y	64	Y	10	Yes	N
							Cluster average (PPFs A – C)	10		
							Cluster compliance	Y		

A3.4 Mitigation option 2

New road layout at design year with noise mitigation

Determine the assessment details for mitigation option 2 using the following process:

(a) Using an appropriate noise model (see 5.3.2 and A1.2) predict noise levels from the new road at the design year taking into account the predicted traffic flow (AADT), and including solid concrete safety barriers predicted to provide incidental noise mitigation in step A3.2, and a second option of noise mitigation measures as shown in table A18;

(b) Ensure predictions are made for the assessment positions of all PPFs;

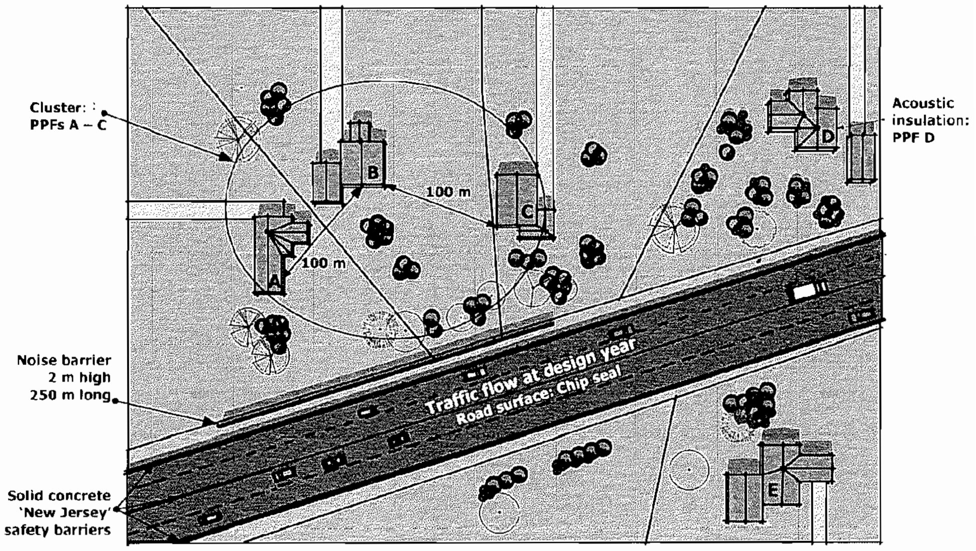
(c) Examine whether or not structural mitigation implemented in this mitigation option will achieve the performance standards specified in 8.2.2;

(d) Determine whether or not any PPFs require building modification mitigation. (In this example PPF D will require acoustic insulation as shown in figure A9.)

Table A18 provides the mitigation option 2 assessment details for example 2. Table A19 provides the mitigation option 2 results for example 2. Figure A9 provides a schematic representation of scenario being assessed.

Table A18 – Example 2 – Step A3.4 Assessment details – Mitigation option 2 – New road layout at design year with noise mitigation

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
AADT (design year)	40,000 vpd	–
Average vehicle speed	100 km/h	–
Heavy commercial vehicles (HCV)	12%	–
Road surface material	Chip seal	–
New road	New road	New road to be constructed in a 'greenfield' rural environment. Solid concrete 'New Jersey' safety barriers installed as part of new road layout
Mitigation option 2	Barriers and insulation	2 m (high) by 250 m (long) noise barrier as shown in figure A9 and acoustic insulation for PPF D
Clusters	1	PPFs A – C in figure A9 form one cluster. PPFs D and E are not part of a cluster


Cluster:
PPFs A – C
Acoustic insulation: PPF D
Noise barrier 2 m high 250 m long
Solid concrete 'New Jersey' safety barriers
A
B
C
D
E
100 m
100 m
Traffic flow at design year
Road surface: Chip seal

Rural environment

Figure A9 – Example 2 – Step A3.4 – Schematic representation – Mitigation option 2 – New road layout at design year with noise mitigation

Table A19 – Example 2 – Step A3.4 Results – Mitigation option 2 – New road layout at design year with structural noise mitigation

PPF	Existing	Do-minimum	Mitigation option 2	Altered road				Structural mitigation performance (see 8.2.2)		Building modification mitigation required?
	External noise level (dB $L_{Aeq(24h)}$)			Category A		Category B		Individual PPF	Individual PPF compliance?	
				Criteria	Option 2 complies?	Criteria	Option 2 complies?	dB $L_{Aeq(24h)}$		
A	43	61	50	57	Y	64	Y	5	Not applicable	N
B	42	62	51	57	Y	64	Y	5	Not applicable	N
C	43	62	55	57	N	64	Y	1	Not applicable	N
D	41	63	59	57	N	64	N	-2	No	Y
E	46	66	56	57	N	64	Y	4	No	N
							Cluster average (PPFs A – C)	4		
							Cluster compliance	Y		

A3.5 Comparison of mitigation options

Using the information from tables A17 and A19, compare the relative effectiveness and merits of each mitigation option with a view to determining the best practicable option. The two mitigation options are described in table A20 and are compared in table A21.

Table A20 – Example 2 – Mitigation option details

Option number	Detail	Notes
1	Road surface and barriers	OGPA low-noise road surface and 2 m (high) by 420 m (long) noise barrier installed as part of new road layout shown in figure A8
2	Barriers and insulation	2 m (high) by 250 m (long) noise barrier as shown in figure A9 and acoustic insulation for PPF D

Table A21 – Example 2 – Comparison of mitigation options

Detail	Mitigation option 1	Mitigation option 2
Structural mitigation	Noise barrier	
	2 m (high) by 420 m (long)	2 m (high) by 250 m (long)
Road surface material	Low-noise road surface	
	OGPA	Not applicable
	OGPA	Chip seal
Building modification mitigation	Number of PPFs = 0	Number of PPFs = 1
Altered road noise criteria compliance	Category A = 80% (4 of 5)	Category A = 40% (2 of 5)
	Category B = 100% (5 of 5)	Category B = 80% (4 of 5)
	Category C = Not applicable	Category C = 100% (1 of 1)
Structural mitigation performance compliance	Clusters = 100% (1 of 1)	Clusters = 100% (1 of 1)
	Individual PPFs = 50% (1 of 2)	Individual PPFs = 0% (0 of 2)
Rank by preference	1	2

CA3.5 *A benefit-cost analysis could also be undertaken of each noise mitigation option using the methodology provided in Appendix D. This analysis would provide additional information to assist the decision-making process identifying the best practicable option.*

A3.6 Discussion

From a noise management perspective mitigation option 1 is preferred to option 2. Compared to option 2, option 1 achieves greater compliance with the Category A criterion for new roads (with an AADT less than 75,000 vpd). In addition, since noise levels at all PPFs comply with the relevant Category B criterion in option 1 there is no need for building modification mitigation such as acoustic insulation. For option 2, the choice of structural mitigation does not achieve compliance with the Category B criterion at one PPF. As the internal noise level at this dwelling is predicted to be above 45 dB $L_{Aeq(24h)}$, building modification mitigation measures in the form of acoustic insulation would need to be offered to this PPF.

The development of mitigation options is an iterative process. Therefore it is essential that there is early and ongoing dialogue between the acoustician(s) responsible for the noise assessment and specialists from other disciplines, such as traffic engineers, urban designers, planners, property managers, archaeologists, and quantity surveyors. These specialists might raise issues such as safety, visual appearance, cost, or effects on historic places that also need to be taken into account. As a result, mitigation option 2 or a modified version of mitigation option 1 might represent the best practicable option, for example if the current mitigation option 1 gives rise to unacceptable heritage issues at certain PPFs.

A4 EXAMPLE 3 – ALTERED ROAD – SPECIAL CASE

DEVELOPMENT OF A NEW INTERSECTION TO CONNECT A NEW ROAD AND AN EXISTING ROAD IN A RURAL ENVIRONMENT

A4.1 Existing noise environment

Current road layout at date of assessment

Greenfield situation at date of assessment

Determine the existing noise environment using the following process:

(a) Undertake screening assessment to determine application of this Standard (see 1.3.1(d));

(b) As the roading project is in a rural environment, identify all PPFs within 200 m of the edge of the closest new and/or altered traffic lane (see 1.4.2). In this example the PPFs are all single-storey residential dwellings with one assessment position each, and are labelled A – D in figure A10;

(c) Measure existing ambient sound levels at assessment position(s) representative of the PPFs shown in figure A10;

(d) Determine the existing noise environment at the assessment positions of all PPFs using the measurements taken and/or calibrated noise model predictions (see section 5 and CA4.1).

Table A22 provides the existing noise environment assessment details for example 3. Table A23 provides the results of the existing noise environment assessment. Figure A10 provides a schematic representation of scenario being assessed.

Table A22 – Example 3 – Step A4.1 Assessment details – Existing noise environment – Current road layout at date of assessment

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
AADT (design year)	12,000 vpd	–
Average vehicle speed	70 km/h	–
Heavy commercial vehicles (HCV)	10%	–
Road surface material	Chip seal	–

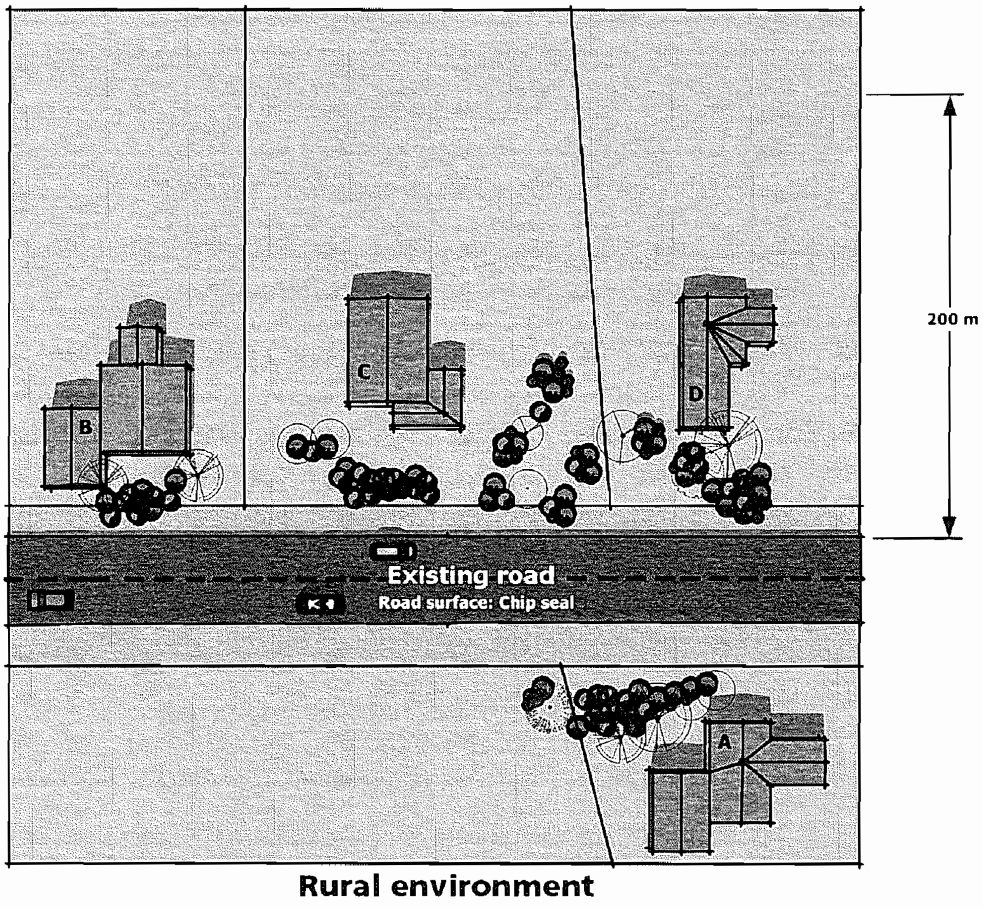


Figure A10 – Example 3 – Step A4.1 – Schematic representation – Existing noise environment – Current road layout at date of assessment

Table A23 – Example 3 – Step A4.1 – Results – Existing noise environment – Current road layout at date of assessment

PPF	Existing External noise level (dB $L_{Aeq(24h)}$)
A	61
B	62
C	63
D	62

NOTE – The existing or 'baseline' noise levels include noise from all existing local roads and state highways in their existing condition. Baseline noise levels also include noise from other noise sources that are situated near to the location of the roading project.

CA4.1 *Although the new road does not currently exist, it is possible to use noise model predictions in this example to determine the existing noise environment. This is because it is a special case (see 6.2) where a new road is being tied in with an existing road. The existing noise environment associated with the existing road can be either measured or predicted.*

Calibrating a noise model for a new road can only be done for locations where existing noise environment measurements are taken in the vicinity of the merge or tie-in between the new road and an existing road. That is, where it is necessary to include predictions of existing road noise in the model.

A4.2 Do-nothing noise environment

Current road layout at design year

Determine the do-nothing noise environment using the following process:

(a) Determine the design year (see 2.2) of the roading project;

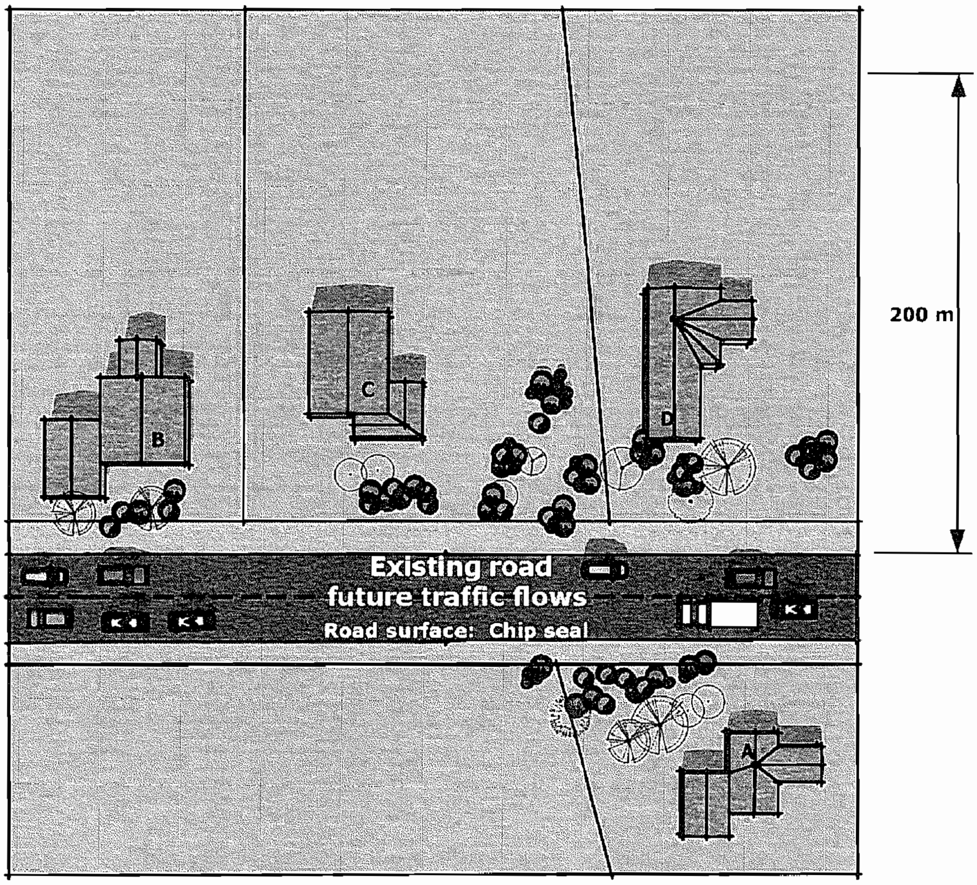
(b) Using an appropriate noise model (see 5.3.2 and A1.2) predict noise levels for the design year taking into account the future traffic flow (AADT), and assuming no alterations are made to the existing road layout;

(c) Ensure predictions are made for the assessment positions of all PPFs.

Table A24 provides the do-nothing noise environment assessment details for example 3. Table A25 provides the results of the do-nothing noise environment assessment. Figure A11 provides a schematic representation of scenario being assessed.

Table A24 – Example 3 – Step A4.2 Assessment details – Do-nothing environment – Current road layout at design year

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
AADT (design year)	15,000 vpd	Increase from existing year due to natural growth in traffic
Average vehicle speed	70 km/h	–
Heavy commercial vehicles (HCV)	12%	–
Road surface material	Chip seal	–



Rural environment

Figure A11 – Example 3 – Step A4.2 – Schematic representation – Do-nothing noise environment – Current road layout at design year

Table A25 – Example 3 – Step A4.2 Results – Do-nothing noise environment – Current road layout at design year

PPF	Existing	Do-nothing
	External noise level (dB $L_{Aeq(24h)}$)	
A	61	62
B	62	63
C	63	64
D	62	63

CA4.2 *The predicted design year do-nothing noise levels assume all existing local roads and state highways are in their current location and condition. Depending on circumstances this may mean an increase or decrease of traffic volumes due to other roading projects and developments in the vicinity. Predictions of future traffic flows should comply with the requirements of 1.2.3.*

A4.3 Do-minimum noise environment

New road intersection at design year without specific noise mitigation

Determine the do-minimum noise environment using the following process:

(a) Using a noise model, predict noise levels from the new and altered road at the design year taking into account the predicted traffic flow (AADT), and including safety barriers and any other structures which may have incidental noise mitigating effects. In this example there are no provisions to include safety barriers or other structures which could provide incidental noise mitigation (see CA4.3);

(b) Ensure calibrated noise model predictions are made for the assessment positions of all PPFs (see CA4.1);

(c) Review the existing noise environment and compare the predictions for the do-minimum noise environment with those for the do-nothing environment to confirm that the roading project is an altered road as defined in this Standard (see 1.5.2, 6.2, and CA4.3);

(d) Identify the relevant noise criteria from table 2 for an altered road.

Table A26 provides the existing noise environment assessment details for example 3. Table A27 provides the results of the existing noise environment assessment. Figure A12 provides a schematic representation of scenario being assessed.

Table A26 – Example 3 – Step A4.3 Assessment details – Do-minimum noise environment – New intersection at design year without specific noise mitigation

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
New road/Altered road	New intersection	New road to be constructed in a rural environment connecting to an existing road. New intersection will change the horizontal alignment of existing road
Existing road		
AADT (design year)	20,000 vpd	Changes from existing year due to alterations and natural growth in traffic
Average vehicle speed	80 km/h	
Heavy commercial vehicles (HCV)	10%	
Road surface material	Chip seal	
New road		
AADT (design year)	25,000 vpd	–
Average vehicle speed	100 km/h	–
Heavy commercial vehicles (HCV)	12%	–
Road surface material	Chip seal	–

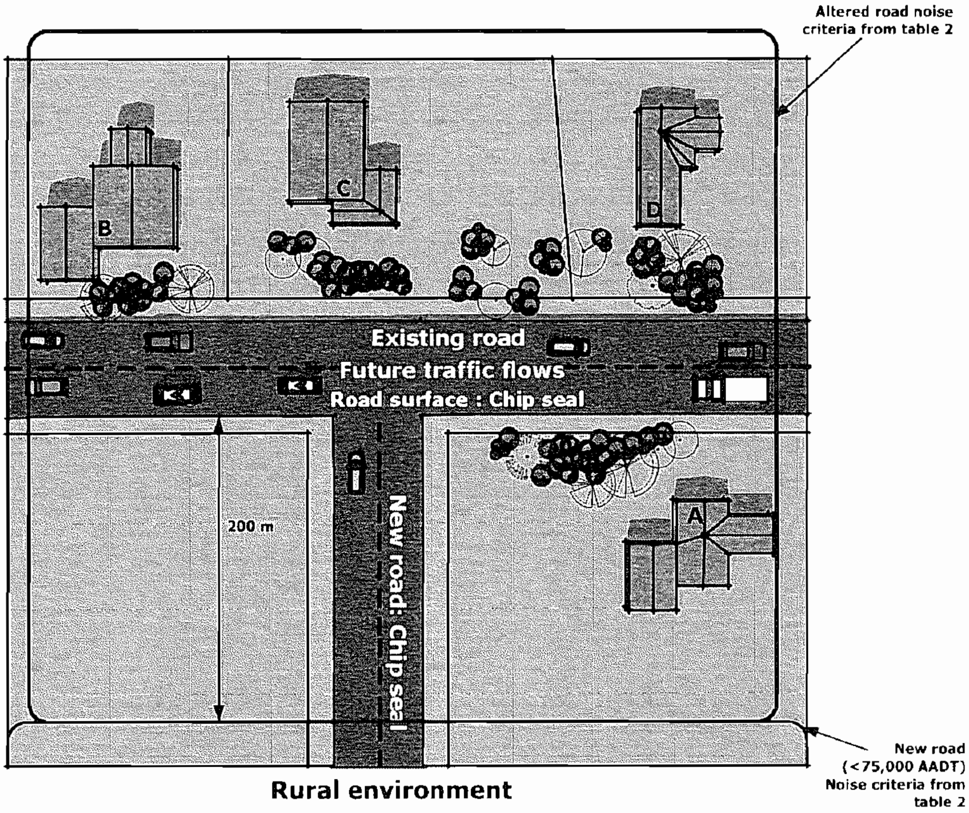


Figure A12 – Example 3 – Step A4.3 – Schematic representation – Do-minimum noise environment – New intersection at design year without specific noise mitigation

Table A27 – Example 3 – Step A4.3 Results – Do-minimum noise environment – New intersection at design year without specific noise mitigation

PPF	Existing	Do-nothing	Do-minimum	Altered road		
	External noise level (dB $L_{Aeq(24h)}$)			Threshold exceeded (see 1.5.2)	Noise criteria	
					Category A	Category B
A	61	62	68	Y	64	67
B	62	63	64	N	64	67
C	63	64	65	N	64	67
D	62	63	64	N	64	67

CA4.3 *No measures specifically designed for noise mitigation should be included in the predictions of the do-minimum noise environment.*

Although this example involves the assessment of a new road, because this example is a special case (see 6.2) where the new road ties in with an existing road, the altered road noise criteria from table 2 have been applied. This takes account of the existing noise environment and the noise effect of the alterations to the existing road at PPFs near the new intersection.

In this example, because the roading project is in a rural environment the altered road criteria would be applied to all PPF within 200 m of a new traffic lane at the intersection. PPFs located beyond this distance but still within 200 m of the new road alignment would be subject to the application of the new road noise criteria (with an AADT of less than 75,000) – see also figure A12.

If the do-minimum noise levels predicted for all PPFs are less than the altered road Category A criterion (64 dB $L_{Aeq(24h)}$) from table 2 then no specific noise mitigation measures would be required.

Since one or more of the thresholds specified in 1.5.2 are exceeded at one or more relevant PPF, the roading project is an altered road as defined in 1.5. The Standard should therefore be applied to all PPFs identified in step A4.1(b). Since there are fewer than ten PPFs, at least two mitigation options should be developed (see table 3).

A4.4 Mitigation option 1

New intersection at design year with noise mitigation

Determine the assessment details for mitigation option 1 using the following process:

(a) Using an appropriate noise model (see 5.3.2 and A1.2) predict noise levels at the design year with the roading project implemented taking into account the predicted traffic flow (AADT), and a first option of noise mitigation measures as shown in table A28;

(b) Ensure predictions are made for the assessment positions of all PPFs;

(c) Identify which PPFs are parts of a cluster as defined in 2.2. In this example the assessment positions of the PPFs labelled B – D in figure A13 are within 100 m of each other and are also on the same side of the altered road. These PPFs form a single cluster. PPF A is not part of a cluster;

(d) Examine whether or not structural mitigation implemented in this mitigation option will achieve the performance standards specified in 8.2.2 (see CA4.3);

(e) Determine whether or not any PPFs require building modification mitigation.

Table A28 provides the mitigation option 1 assessment details for example 3. Table A29 provides the mitigation option 1 results for example 3. Figure A13 provides a schematic representation of scenario being assessed.

Table A28 – Example 3 – Step A4.4 Assessment details – Mitigation option 1 – New road intersection at design year with noise mitigation

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
New road/Altered road	New intersection	New road to be constructed in a rural environment connecting to an existing road. New road will change the horizontal alignment of the existing road
Mitigation option 1	Barrier	2 m (high) by 120 m (long) noise barrier for PPF A as shown in figure A13
Clusters	1	PPFs B – D shown in figure A13 form a cluster. PPF A is not part of a cluster
Existing road		
AADT (design year)	20,000 vpd	Changes from existing year due to alterations and natural growth in traffic
Average vehicle speed	80 km/h	
Heavy commercial vehicles (HCV)	10%	
Road surface material	Chip seal	
New road		
AADT (design year)	25,000 vpd	–
Average vehicle speed	100 km/h	–
Heavy commercial vehicles (HCV)	12%	–
Road surface material	Chip seal	–

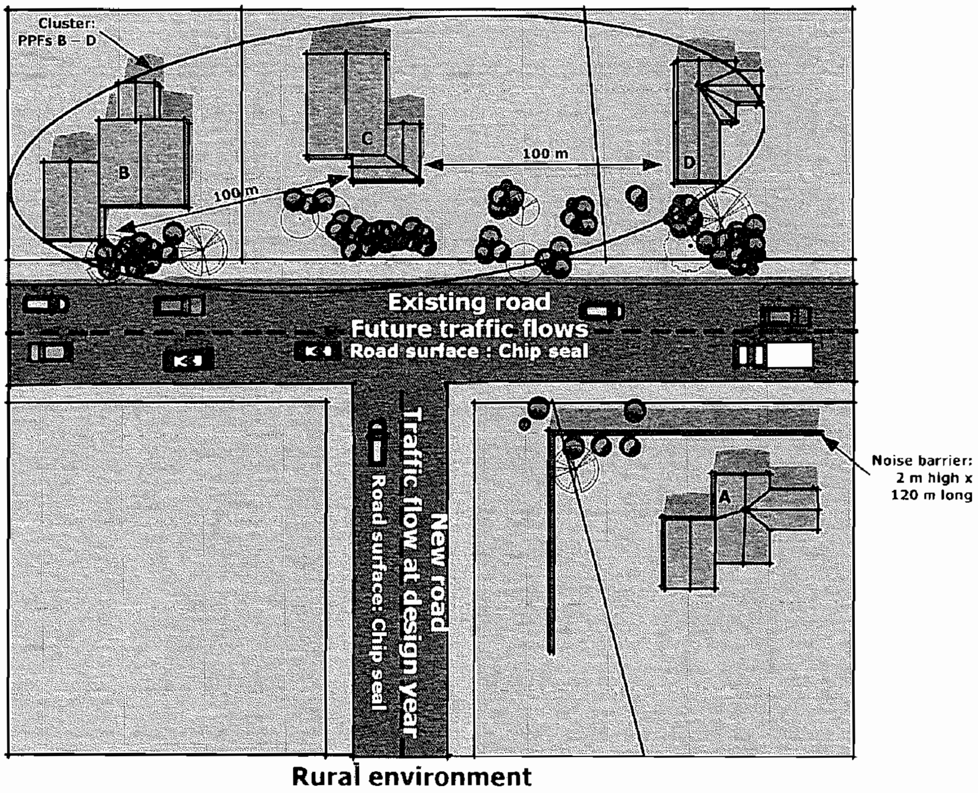


Figure A13 – Example 3 – Step A4.4 – Schematic representation – Mitigation option 1 – New intersection at design year with noise mitigation

Table A29 – Example 3 – Step A4.4 Results – Mitigation option 1 – New intersection at design year with structural noise mitigation

PPF	Existing	Do-nothing	Do-minimum	Mitigation option 1	Altered road				Structural mitigation performance (see 8.2.2)		Building modification mitigation required?
	External noise level (dB $L_{Aeq(24h)}$)				Category A		Category B		Individual PPF	Individual PPF compliance?	
					Criteria	Option 1 complies?	Criteria	Option 1 complies?	dB $L_{Aeq(24h)}$		
A	61	62	68	60	64	Y	67	Y	8	Y	N
B	62	63	64	64	64	Y	67	Y	0	Not applicable	N
C	63	64	65	65	64	N	67	Y	0	Not applicable	N
D	62	63	64	64	64	Y	67	Y	0	Not applicable	N
								Cluster average (PPFs B – D)	Not applicable		
								Cluster compliance	Not applicable		

CA4.4 *Although PPFs B – D are part of a cluster, the performance standard for clusters specified in 8.2.2(a) does not apply as the mitigation provided in this option is specific to PPF A. That is, a noise barrier to protect this single residential dwelling. The noise barrier protecting PPF A should be assessed using the performance standard specified in 8.2.2(b).*

A4.5 Mitigation option 2

New intersection at design year with noise mitigation

Determine the assessment details for mitigation option 2 using the following process:

(a) Using an appropriate noise model (see 5.3.2 and A1.2) predict noise levels at the design year with the roading project implemented taking into account the predicted traffic flow (AADT), and a second option of noise mitigation measures as shown in table A30;

(b) Ensure predictions are made for the assessment positions of all PPFs;

(c) Examine whether or not structural mitigation implemented in this mitigation option will achieve the performance standards specified in 8.2.2;

(d) Determine whether or not any PPFs require building modification mitigation.

Table A30 provides the mitigation option 2 assessment details for example 3. Table A31 provides the mitigation option 2 results for example 3. Figure A14 provides a schematic representation of scenario being assessed.

Table A30 – Example 3 – Step A4.5 Assessment details – Mitigation option 2 – New intersection at design year with noise mitigation

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
New road/altered road	New intersection	New road to be constructed in a rural environment connecting to an existing road. New road will change the horizontal alignment of the existing road
Mitigation option 2	Road surface	OGPA low-noise road surface
Clusters	1	PPFs B – D in figure A14 form a cluster. PPF A is not part of a cluster
Existing road		
AADT (design year)	20,000 vpd	Changes from existing year due to alterations and natural growth in traffic
Average vehicle speed	80 km/h	
Heavy commercial vehicles (HCV)	10%	
Road surface material	Chip seal	
New road		
AADT (design year)	25,000 vpd	–
Average vehicle speed	100 km/h	–
Heavy commercial vehicles (HCV)	12%	–
Road surface material	Chip seal	–

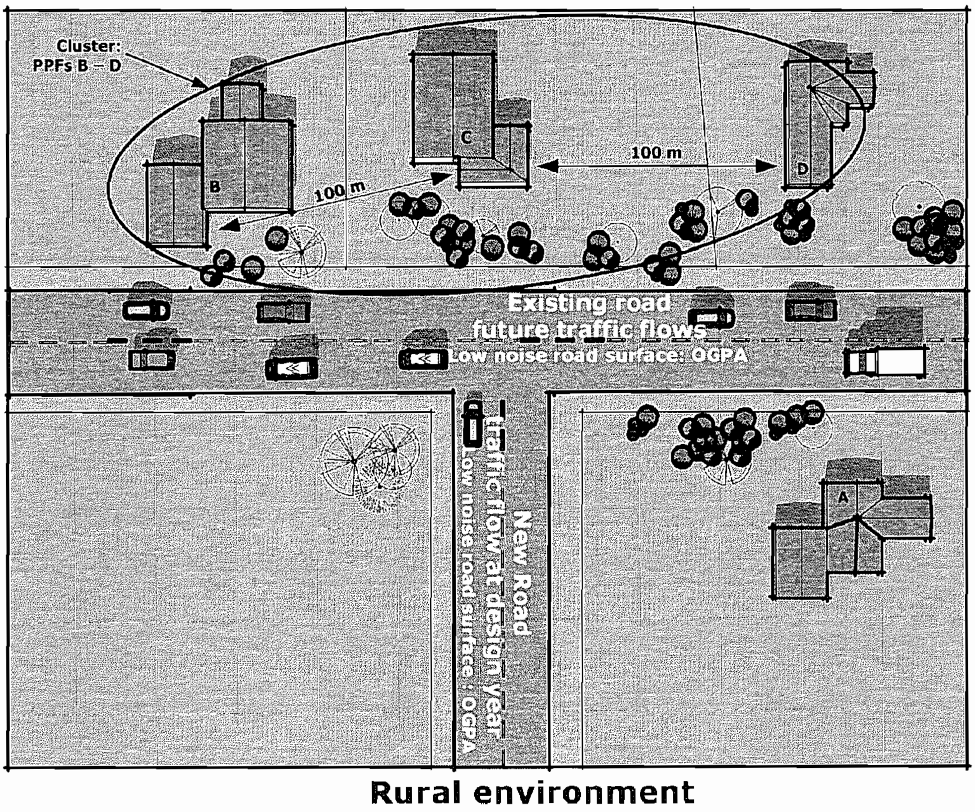


Figure A14 – Example 3 – Step A4.5 – Schematic representation – Mitigation option 2 – New intersection at design year with noise mitigation

Table A31 – Example 3 – Step A4.5 Results – Mitigation option 2 – New intersection at design year with noise mitigation

PPF	**Existing**	**Do-nothing**	**Do-minimum**	**Mitigation option 2**	**Altered road**				**Structural mitigation performance** (see 8.2.2)		**Building modification mitigation required?**
	External noise level (dB $L_{Aeq(24h)}$)				**Category A**		**Category B**		**Individual PPF**	**Individual PPF compliance?**	
					Criteria	**Option 2 complies?**	**Criteria**	**Option 2 complies?**	**dB $L_{Aeq(24h)}$**		
A	61	62	68	65	64	N	67	Y	3	Y	N
B	62	63	64	61	64	Y	67	Y	3	Not applicable	N
C	63	64	65	62	64	Y	67	Y	3	Not applicable	N
D	62	63	64	61	64	Y	67	Y	3	Not applicable	N
								Cluster average (PPFs B – D)	3		
								Cluster compliance	Y		

A4.6 Mitigation option 3

New intersection at design year with noise mitigation

Determine the assessment details for mitigation option 3 using the following process:

(a) Using an appropriate noise model (see 5.3.2) predict noise levels at the design year with the roading project implemented taking into account the predicted traffic flow (AADT), and a third option of noise mitigation measures as shown in table A32;

(b) Ensure predictions are made for the assessment positions of all PPFs;

(c) Examine whether or not structural mitigation implemented in this mitigation option will achieve the performance standards specified in 8.2.2;

(d) Determine whether or not any PPFs require building modification mitigation.

Table A32 provides the mitigation option 3 assessment details for example 3. Table A33 provides the mitigation option 3 results for example 3. Figure A15 provides a schematic representation of scenario being assessed.

Table A32 – Example 3 – Step A4.5 Assessment details – Mitigation option 3 – New intersection at design year with noise mitigation

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
New road/altered road	New intersection	New road to be constructed in a rural environment connecting to an existing road. New road will change the horizontal alignment of the existing road
Mitigation option 3	Road surface and barrier	OGPA low-noise road surface and 2 m (high) by 120 m (long) noise barrier for PPF A as shown in figure A15
Clusters	1	PPFs B – D in figure A15 form a cluster. PPF A is not part of a cluster
Existing road		
AADT (design year)	20,000 vpd	Changes from existing year due to alterations and natural growth in traffic
Average vehicle speed	80 km/h	
Heavy commercial vehicles (HCV)	10%	
Road surface material	OGPA	OGPA installed specifically as structural noise mitigation
New road		
AADT (design year)	25,000 vpd	–
Average vehicle speed	100 km/h	–
Heavy commercial vehicles (HCV)	12%	–
Road surface material	OGPA	OGPA installed specifically as structural noise mitigation

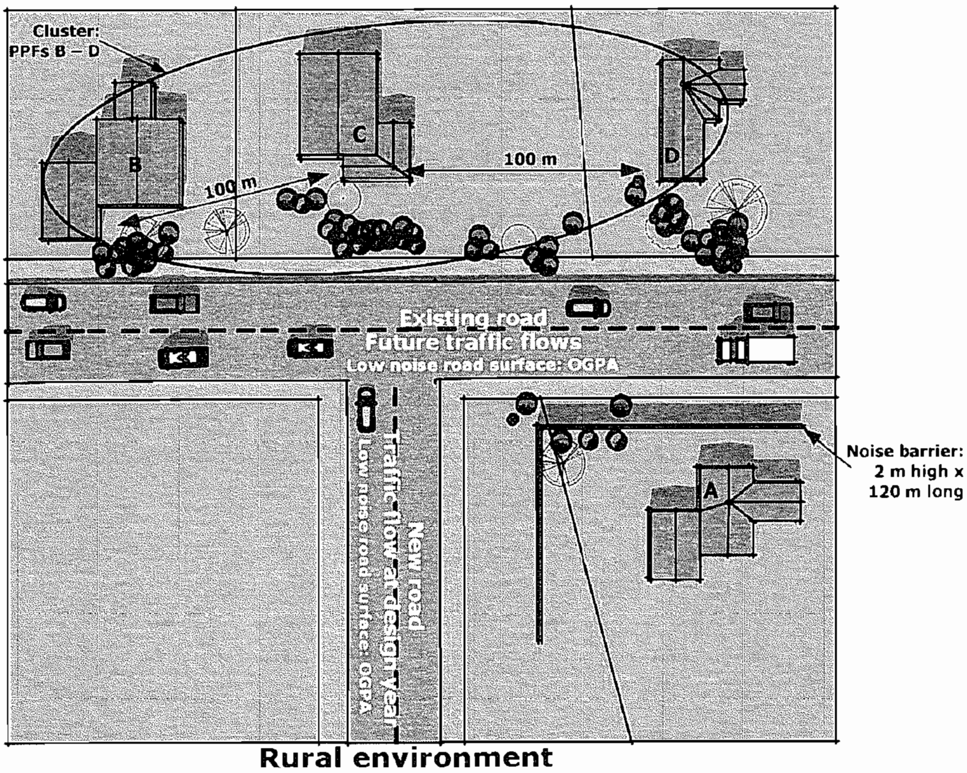


Figure A15 – Example 3 – Step A4.6 – Schematic representation – Mitigation option 3 – New intersection at design year with noise mitigation

Table A33 – Example 3 – Step A4.6 Results – Mitigation option 3 – New intersection at design year with noise mitigation

PPF	Existing	Do-nothing	Do-minimum	Mitigation option 3	Altered road				Structural mitigation performance (see 8.2.2)	
	External noise level (dB $L_{Aeq(24h)}$)				Category A		Category B		Individual PPF	Individual PPF compliance?
					Criteria	Option 3 complies?	Criteria	Option 3 complies?	dB $L_{Aeq(24h)}$	
A	61	62	68	65	64	N	67	Y	3	Y
B	62	63	64	61	64	Y	67	Y	3	Not applicable
C	63	64	65	62	64	Y	67	Y	3	Not applicable
D	62	63	64	61	64	Y	67	Y	3	Not applicable
								Cluster average (PPFs B – D)	3	
								Cluster compliance	Y	

A4.7 Comparison of mitigation options

Using the information from tables A29, A31 and A33, compare the relative effectiveness and merits of each mitigation option with a view to determining the best practicable option. The three mitigation options are described in table A34 and are compared in table A35.

Table A34 – Example 3 – Mitigation option details

Option number	Detail	Notes
1	Barrier	2 m (high) by 120 m (long) noise barrier for PPF A as shown in figure B13
2	Road surface	OGPA low-noise road surface
3	Road surface and barrier	OGPA low-noise road surface and 2 m (high) by 120 m (long) noise barrier for PPF A as shown in figure A15

Table A35 – Example 3 – Comparison of mitigation options

Detail	Mitigation option 1	Mitigation option 2	Mitigation option 3
Structural mitigation	Noise barrier		
	2 m (high) by 120 m (long)	Not applicable	2 m (high) by 120 m (long)
	Low-noise road surface		
	Not applicable	OGPA	OGPA
Road surface material	Chip seal	OGPA	OGPA
Building modification mitigation	Number of PPFs = 0	Number of PPFs = 0	Number of PPFs = 0
Altered road noise criteria compliance	Category A = 75% (3 of 4)	Category A = 75% (3 of 4)	Category A = 100% (4 of 4)
	Category B = 100% (4 of 4)	Category B = 100% (4 of 4)	Category B = 100% (4 of 4)
	Category C = Not applicable	Category C = Not applicable	Category C = Not applicable
Structural mitigation performance compliance	Not applicable	Clusters = 0% (0 of 1)	Clusters = 100% (1 of 1)
	Individual PPFs = 100% (1 of 1)	Individual PPFs = 100% (1 of 1)	Individual PPFs = 100% (1 of 1)
Rank by preference	2	1	3

CA4.7 *A benefit-cost analysis could also be undertaken of each noise mitigation option using the methodology provided in Appendix D. This would provide additional information to assist the decision-making process identifying the best practicable option.*

A4.8 Discussion

From a noise management perspective mitigation option 2 is preferred to the other two options. Although both options provide the same degree of compliance with both the Category A and B criteria for altered roads, option 2 provides a greater reduction in exposure to road traffic noise at those PPFs which are part of a cluster (PPFs B – D). Although option 3 achieves compliance at all PPFs with the Category A criterion, the merits of installing a noise barrier in addition to a low-noise road surface for a single PPF that exceeds Category A by only 1 dB in the other options would require significant justification.

The development of mitigation options is an iterative process. Therefore it is essential that there is early and ongoing dialogue between the acoustician(s) responsible for the noise assessment and specialists from other disciplines, such as traffic engineers, urban designers, planners, property managers, archaeologists, and quantity surveyors. These specialists might raise issues such as safety, visual appearance, cost, or effects on historic places that also need to be taken into account. As a result, mitigation option 1 rather than option 2 might represent the best practicable option, for example if the use of OGPA as a specific noise mitigation measures gives rise to unjustifiable project costs.

A5 EXAMPLE 4 – ALTERED ROAD

ALTERATION OF AN EXISTING ROAD IN AN URBAN ENVIRONMENT INVOLVING THE REPLACEMENT OF A ROUNDABOUT WITH A SIGNALISED INTERSECTION

A5.1 Existing noise environment

Current road layout at date of assessment

Determine the existing noise environment using the following process:

(a) Undertake screening assessment to determine application of this Standard (see 1.3.1(d));

(b) As the roading project is in an urban environment, identify all PPFs within 100 m of the edge of the closest altered traffic lane (see 1.4.2). (In this example the PPFs are all single-storey residential dwellings with one assessment position each, and are labelled A – F in figure A16);

(c) Measure existing ambient sound levels at assessment position(s) representative of the PPFs shown in figure A16;

(d) Determine the existing noise environment at the assessment positions of all PPFs using the measurements taken and/or calibrated noise model predictions (see section 5).

Table A36 provides the existing noise environment assessment details for example 4. Table A37 provides the results of the existing noise environment assessment. Figure A16 provides a schematic representation of scenario being assessed.

Table A36 – Example 4 – Step A5.1 Assessment details – Existing noise environment – Current road layout at date of assessment

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
New road/altered road	New intersection	–
AADT (design year)	12,000 vpd	–
Average vehicle speed	40 km/h	–
Heavy commercial vehicles (HCV)	10%	–
Road surface material	Chip seal	–

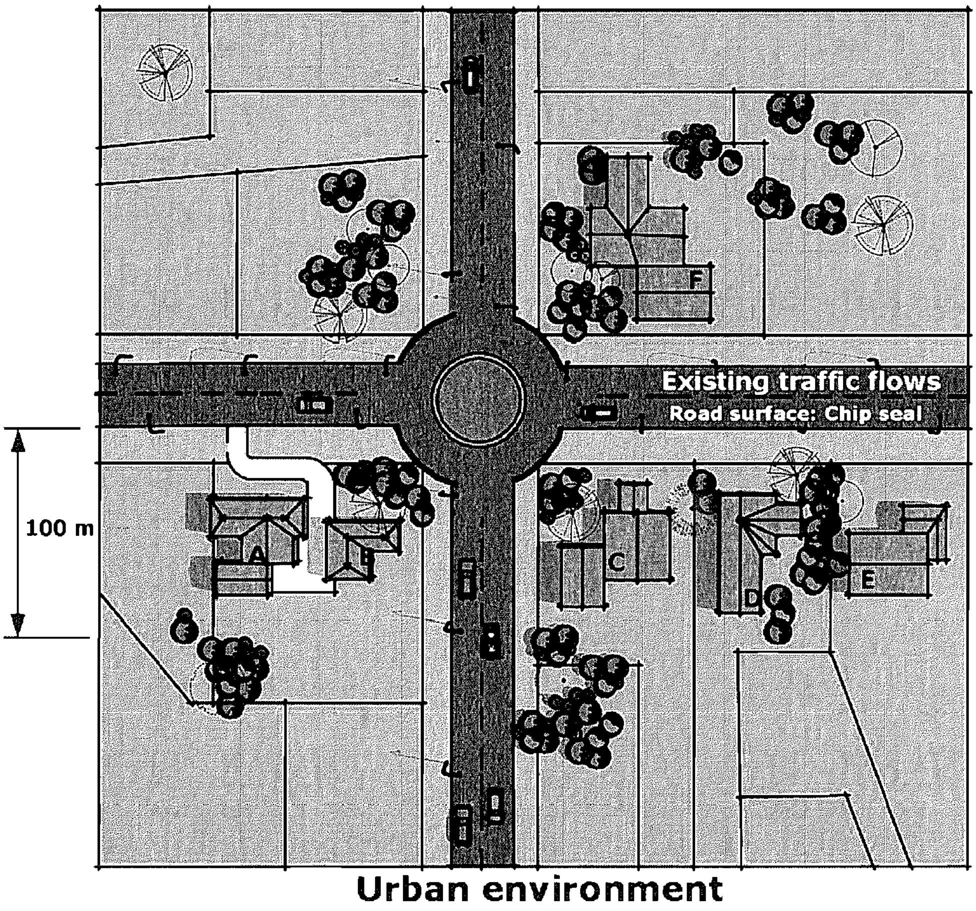


Figure A16 – Example 4 – Step A5.1 – Schematic representation – Existing noise environment – Current road layout at date of assessment

Table A37 – Example 4 – Step A5.1 Results – Existing noise environment – Current road layout at date of assessment

PPF	Existing **External noise level** (dB $L_{Aeq(24h)}$)
A	73
B	72
C	68
D	67
E	67
F	70

NOTE – The existing or 'baseline' noise levels shown include noise from all existing local roads and state highways in their existing condition. Baseline noise levels also include noise from industry as well as other noise sources that are situated near to the location of the roading project.

A5.2 Do-nothing noise environment

Current road layout at design year

Determine the do-nothing noise environment using the following process:

(a) Determine the design year (see 2.2) of the roading project;

(b) Using an appropriate noise model (see 5.3.2) predict noise levels for the design year taking into account the future traffic flow (AADT), and assuming no alterations are made to the existing road layout;

(c) Ensure predictions are made for the assessment positions of all PPFs.

Table A38 provides the existing noise environment assessment details for example 4. Table A39 provides the results of the existing noise environment assessment. Figure A17 provides a schematic representation of scenario being assessed.

Table A38 – Example 4 – Step A5.2 Assessment details – Do-nothing noise environment – Current road layout at design year

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
AADT (design year)	12,000 vpd	Increase from existing year due to natural growth in traffic
Average vehicle speed	40 km/h	–
Heavy commercial vehicles (HCV)	10%	–
Road surface material	Chip seal	–

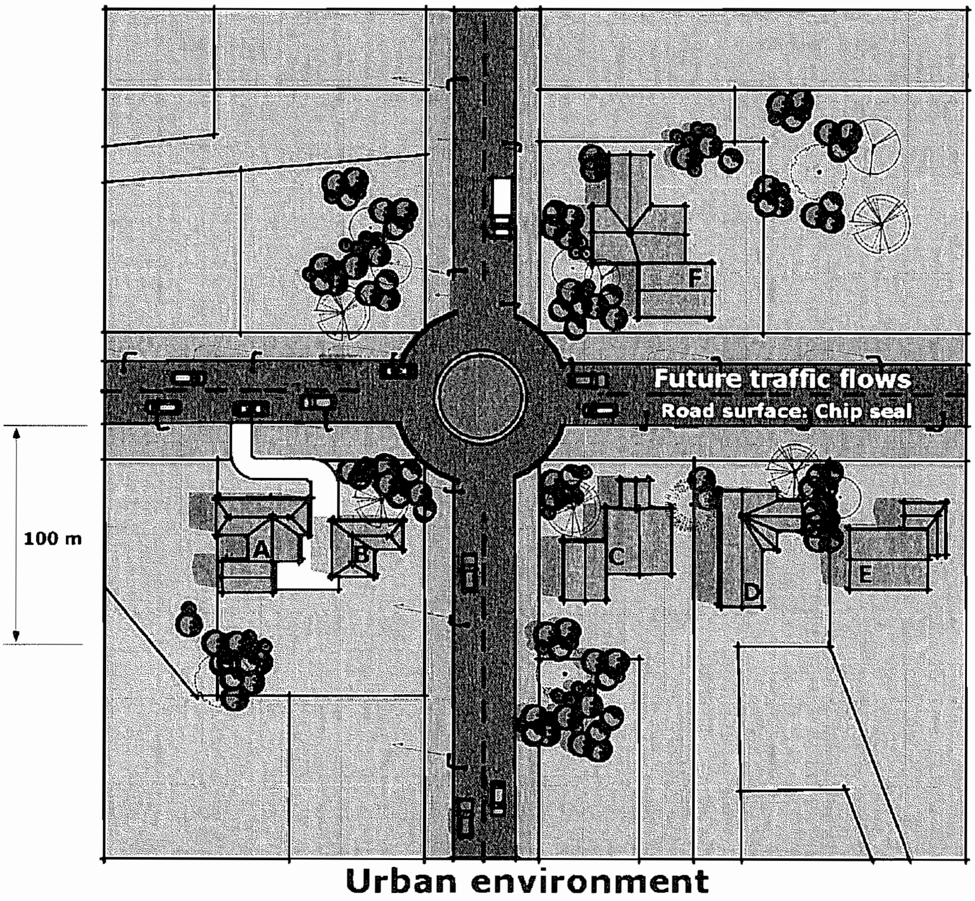


Figure A17 – Example 4 – Step A5.2 – Schematic representation – Do-nothing noise environment – Current road layout at design year

Table A39 – Example 4 – Step A5.2 Results – Do-nothing noise environment – Current road layout at design year

PPF	Existing	Do-nothing
	External noise level (dB $L_{Aeq(24h)}$)	
A	73	74
B	72	73
C	68	69
D	67	68
E	67	68
F	70	71

CA5.2 *The predicted design year do-nothing noise levels assume all existing local roads and state highways are in their current location and condition. Depending on circumstances this may mean an increase or decrease of traffic volumes due to other roading projects and developments in the vicinity. Predictions of future traffic flows should comply with the requirements of 1.2.3.*

A5.3 Do-minimum noise environment

Future road layout at design year without specific noise mitigation

Determine the do-minimum noise environment using the following process:

(a) Using an appropriate noise model (see 5.3.2) predict noise levels at the design year, taking into account the future traffic flow (AADT), and including safety barriers and/or other structures which may have an incidental noise mitigating effect. In this example a SMA surface will replace the existing chip seal surface as part of the alterations for safety reasons, irrespective of any potential noise effects. This road surface is predicted to provide incidental noise mitigation (see CB5.3);

(b) Ensure predictions are made for the assessment positions of all PPFs;

(c) Review existing noise environment and compare the predictions for the do-minimum noise environment with those for the do-nothing environment to confirm that the roading project is an altered road (see 1.5.2);

(d) Identify the relevant noise criteria from table 2 for an altered road.

Table A40 provides the existing noise environment assessment details for example 4. Table A41 provides the results of the existing noise environment assessment. Figure A18 provides a schematic representation of scenario being assessed.

Table A40 – Example 4 – Step A5.3 Assessment details – Do-minimum noise environment – Future road layout at design year without specific noise mitigation

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
AADT (design year)	15,000 vpd	Increase from existing year due to natural growth in traffic
Average vehicle speed	50 km/h	–
Heavy commercial vehicles (HCV)	10%	–
Road surface material	SMA	SMA installed as part of alterations
Altered road layout	Signalised intersection	Signals to replace existing roundabout. Change to horizontal alignment will move road closer to PPFs A and B

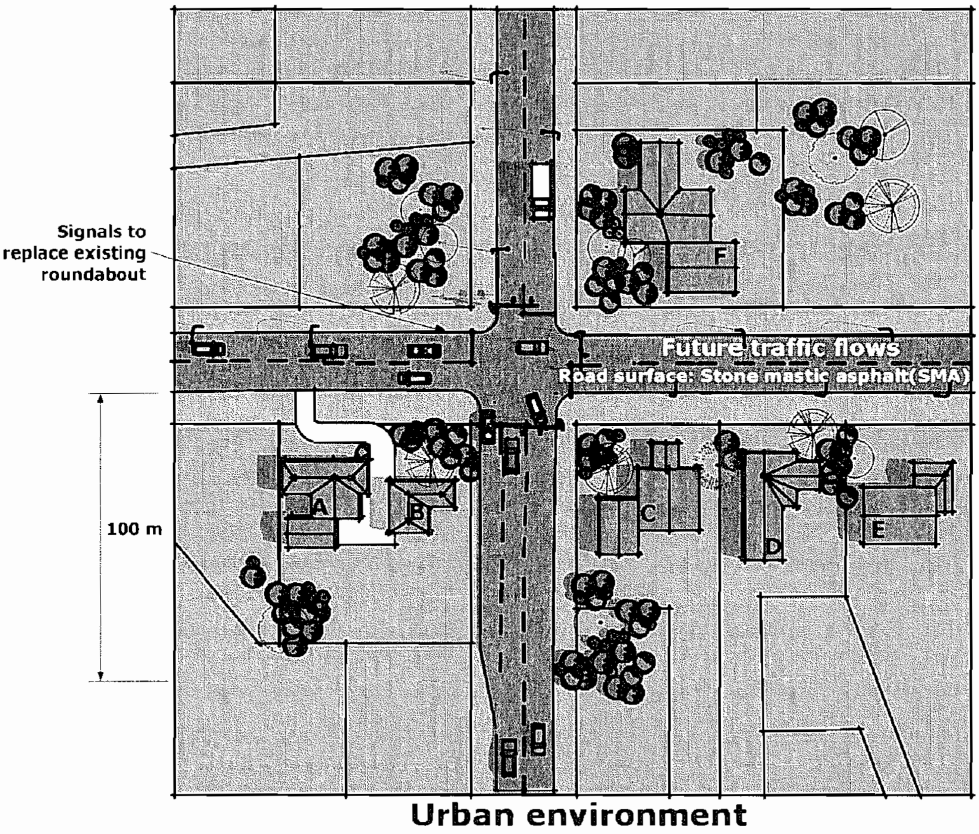

Signals to replace existing roundabout
Future traffic flows
Road surface: Stone mastic asphalt(SMA)
100 m
A
B
C
D
E
F
Urban environment

Figure A18 – Example 4 – Step A5.3 – Schematic representation – Do-minimum noise environment – Future road layout at design year without specific noise mitigation

Table A41 – Example 4 – Step A5.3 Schematic representation – Do-minimum noise environment – Future road layout at design year without specific noise mitigation

PPF	Existing	Do-nothing	Do-minimum	Altered road		
	External noise level (dB $L_{Aeq(24h)}$)			Threshold exceeded (see 1.5.2)	Noise criteria	
					Category A	Category B
A	73	74	76	Y	64	67
B	72	73	74	Y	64	67
C	68	69	65	N	64	67
D	67	68	64	N	64	67
E	67	68	64	N	64	67
F	70	71	67	N	64	67

CA5.3 *No measures specifically designed for noise mitigation should be included in the predictions of the do-minimum noise environment.*

If the do-minimum noise levels predicted for all PPFs are less than the altered road Category A criterion (64 dB $L_{Aeq(24h)}$) from table 2 then no specific noise mitigation measures would be required.

Since one or more of the thresholds specified in 1.5.2 are exceeded at one or more relevant PPF, the roading project is an altered road as defined section 1.5. The Standard should therefore be applied to all PPFs identified in step A5.1(a). Since there are fewer than ten PPFs at least two mitigation options should be developed (see table 3).

A5.4 Mitigation option 1

Future road layout at design year with noise mitigation

Determine the assessment details for mitigation option 1 using the following process:

(a) Using an appropriate noise model (see 5.3.2) predict noise levels at the design year with the roading project implemented taking into account the predicted traffic flow (AADT), and including SMA road surface predicted to provide incidental noise mitigation in step A5.3, and a first option of noise mitigation measures as shown in table A42;

(b) Ensure predictions are made for the assessment positions of all PPFs;

(c) Identify which PPFs are parts of a cluster as defined in 2.2. (In this example the assessment positions of all PPFs labelled C – E in figure A19 are within 100 m of each other and are also on the same side of the altered road. That is, the same corner of the intersection.) These PPFs form a single cluster;

(d) Examine whether or not structural mitigation implemented in this mitigation option will achieve the performance standards specified in 8.2.2;

(e) Determine whether or not any PPFs require building modification mitigation.

Table A42 provides the mitigation option 1 assessment details for example 4. Table A43 provides the mitigation option 1 results for example 4. Figure A19 provides a schematic representation of scenario being assessed.

Table A42 – Example 4 – Step A5.4 Assessment details – Mitigation option 1 – Future road layout at design year with noise mitigation

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
AADT (design year)	15,000 vpd	Increase from existing year due to natural growth in traffic
Average vehicle speed	50 km/h	Increase due to alterations
Heavy commercial vehicles (HCV)	10%	–
Road surface material	SMA	SMA installed as part of alterations
Altered road layout	Signalised intersection	Signals to replace existing roundabout. Change to horizontal alignment will move road closer to PPFs A and B
Mitigation option 1	Barriers	2 m (high) by 80 m (long) noise barrier as shown in figure A19. Noise barrier for PPFs A and B has a gap to provide vehicle access to dwellings from altered road
Clusters	1	PPFs C – E in figure A19 from one cluster. PPFs A, B, and F are not part of a cluster

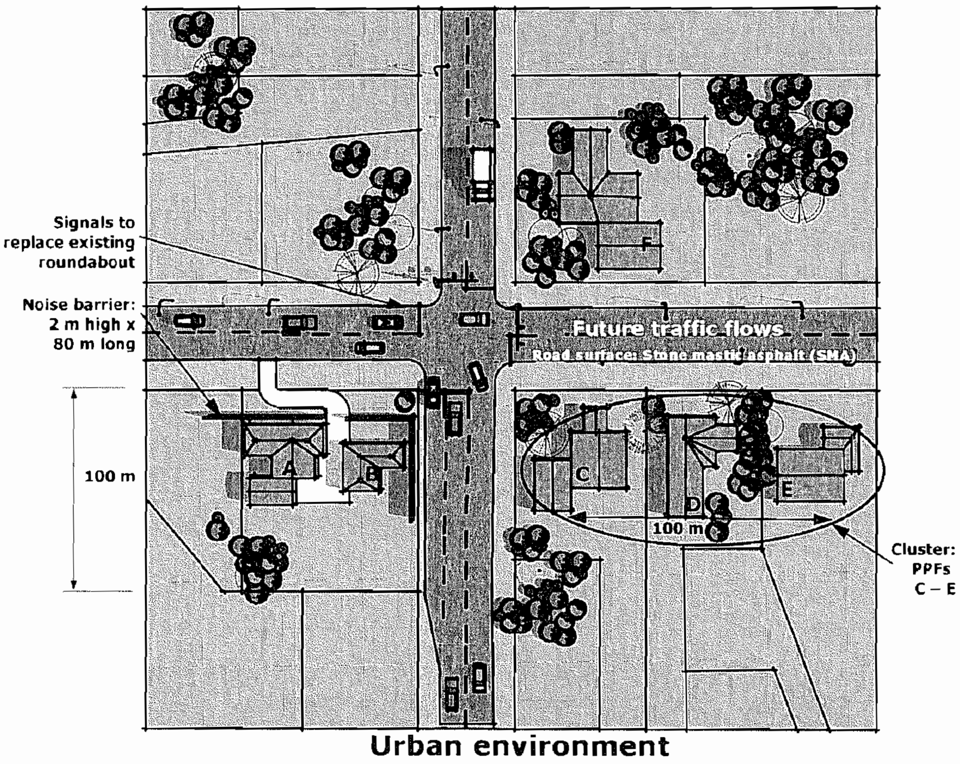

Signals to replace existing roundabout
Noise barrier: 2 m high x 80 m long
100 m
Future traffic flows
Road surface: Stone mastic asphalt (SMA)
A
B
C
D
E
F
100 m
Cluster: PPFs C – E
Urban environment

Figure A19 – Example 4 – Step A5.4 – Schematic representation – Mitigation option 1 – Future road layout at design year with noise mitigation

Table A43 – Example 4 – Step A5.4 Results – Mitigation option 1 – Future road layout at design year with noise mitigation

PPF	Existing	Do-nothing	Do-minimum	Mitigation option 1	Altered road				Structural mitigation performance (see 8.2.2)		Building modification mitigation required?
	External noise level (dB $L_{Aeq(24h)}$)				Category A		Category B		Individual PPF	Individual PPF compliance?	
					Criteria	Option 1 complies?	Criteria	Option 1 complies?	dB $L_{Aeq(24h)}$		
A	73	74	76	67	64	N	67	Y	9	Y	N
B	72	73	74	67	64	N	67	Y	7	Y	N
C	68	69	65	65	64	N	67	Y	–	Not applicable	N
D	67	68	64	64	64	Y	67	Y	–	Not applicable	N
E	67	68	64	64	64	Y	67	Y	–	Not applicable	N
F	70	71	67	63	64	Y	67	Y	–	N	N
								Cluster average	Not applicable		
								Cluster compliance	Not applicable		

A5.5 Mitigation option 2

Future road layout at design year with noise mitigation

Determine the assessment details for mitigation option 2 using the following process:

(a) Using an appropriate noise model (see 5.3.2) predict noise levels at the design year with the roading project implemented taking into account the predicted traffic flow (AADT), and including a SMA road surface predicted to provide incidental noise mitigation in step A5.3 and a second option of noise mitigation measures as shown in table A44;

(b) Ensure predictions are made for the assessment positions of all PPFs;

(c) Examine whether or not structural mitigation implemented in this mitigation option will achieve the performance standards specified in 8.2.2;

(d) Determine whether or not any PPFs require building modification mitigation. In this example PPFs A and B will require acoustic insulation as shown in figure A20.

Table A44 provides the mitigation option 2 assessment details for example 4. Table A45 provides the mitigation option 2 results for example 4. Figure A20 provides a schematic representation of scenario being assessed.

Table A44 – Example 4 – Step A5.5 Assessment details – Mitigation option 2 – Future road layout at design year with noise mitigation

Parameter	Detail	Notes
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
AADT (design year)	15,000 vpd	Increase from existing year due to natural growth in traffic
Average vehicle speed	50 km/h	Increase due to alterations
Heavy commercial vehicles (HCV)	10%	–
Road surface material	SMA	SMA installed as part of alterations
Altered road layout	Signalised intersection	Signals to replace existing roundabout. Change to horizontal alignment will move road closer to PPFs A and B
Mitigation option 1	Barriers and insulation	2 m (high) by 80 m (long) noise barrier as shown in figure A20 for PPF F and acoustic insulation for PPFs A and B
Clusters	1	PPFs C – E in figure A20 form one cluster. PPFs A, B, and F are not part of a cluster

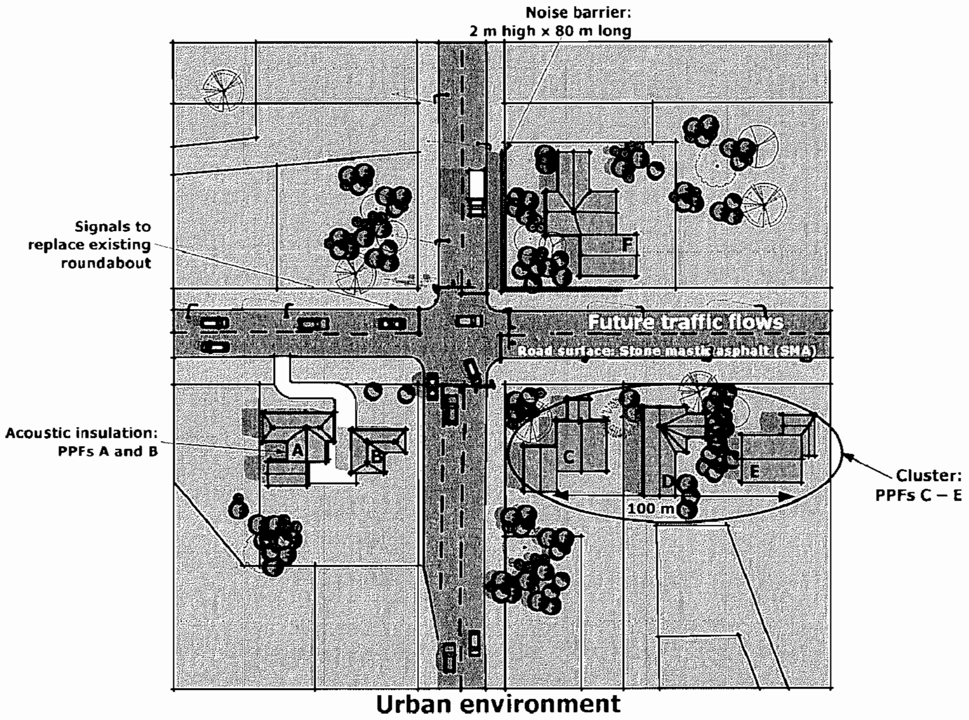


Figure A20 – Example 4 – Step A5.5 – Schematic representation – Mitigation option 2 – Future road layout at design year with noise mitigation

Table A45 – Example 4 – Step A5.5 Results – Mitigation option 2 – Future road layout at design year with noise mitigation

PPF	Existing	Do-nothing	Do-minimum	Mitigation option 2	Altered road				Structural mitigation performance (see 8.2.2)		Building modification mitigation required?
	External noise level (dB $L_{Aeq(24h)}$)				Category A		Category B		Individual PPF	Individual PPF compliance?	
					Criteria	Option 2 complies?	Criteria	Option 2 complies?	dB $L_{Aeq(24h)}$		
A	73	74	76	76	64	N	67	N	–	Not applicable	Y
B	72	73	74	74	64	N	67	N	–	Not applicable	Y
C	68	69	65	65	64	N	67	Y	–	Not applicable	N
D	67	68	64	64	64	Y	67	Y	–	Not applicable	N
E	67	68	64	64	64	Y	67	Y	–	Not applicable	N
F	70	71	67	63	64	Y	67	Y	4	N	N
								Cluster average	Not applicable		
								Cluster compliance	Not applicable		

A5.6 Mitigation option 3

Future road layout at design year with noise mitigation

Determine the assessment details for mitigation option 3 using this process:

(a) Using an appropriate noise model (see 5.3.2), predict noise levels at the design year with the roading project implemented taking into account the predicted traffic flow (AADT), and including a SMA road surface predicted to provide incidental noise mitigation in step A5.3, and a third option of noise mitigation measures as shown in table A46;

(b) Ensure predictions are made for the assessment positions of all PPFs identified in step A5.1(a);

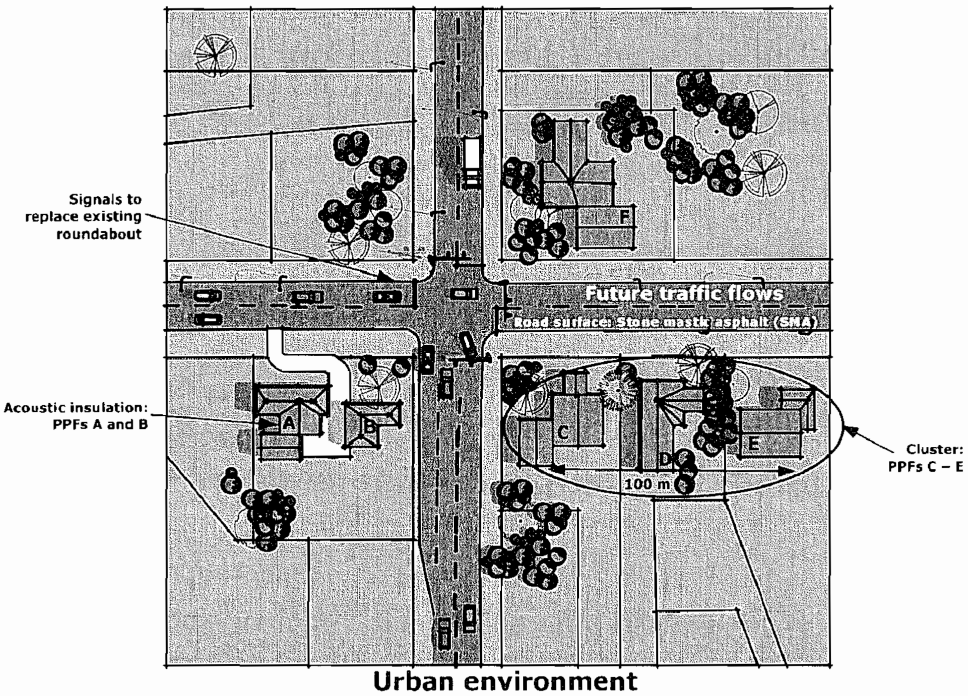
(c) Examine whether or not structural mitigation implemented in this mitigation option will achieve the performance standards specified in 8.2.2;

(d) Determine whether or not any PPFs require building modification mitigation. In this example PPFs A and B will require acoustic insulation as shown in figure A21.

Table A46 provides the mitigation option 3 assessment details for example 4. Table A47 provides the mitigation option 3 results for example 4. Figure A21 provides a schematic representation of scenario being assessed.

Table A46 – Example 4 – Step A5.6 Assessment details – Mitigation option 3 – Future road layout at design year with noise mitigation

Parameter	**Detail**	**Notes**
PPFs	Residential	All PPFs are single-storey residential dwellings with one assessment position
AADT (design year)	15,000 vpd	Increase from existing year due to natural growth in traffic
Average vehicle speed	50 km/h	Increase due to alterations
Heavy commercial vehicles (HCV)	10%	–
Road surface material	SMA	SMA installed as part of alterations
Altered road layout	Signalised intersection	Signals to replace existing roundabout. Change to horizontal alignment will move road closer to PPFs A and B
Mitigation option 1	Insulation	Acoustic insulation for PPFs A and B
Clusters	1	PPFs C – E in figure A21 form one cluster. PPFs A, B, and F are not part of a cluster



Signals to replace existing roundabout

Acoustic insulation: PPFs A and B

Cluster: PPFs C – E

Figure A21 – Example 4 – Step A5.6 – Schematic representation – Mitigation option 3 – Future road layout at design year with noise mitigation

Table A47 – Example 4 – Step A5.6 Results – Mitigation option 3 – Future road layout at design year with noise mitigation

PPF	Existing	Do-nothing	Do-minimum	Mitigation option 3	Altered road				Structural mitigation performance (see 8.2.2)		Building modification mitigation required?
	External noise level (dB $L_{Aeq(24h)}$)				Category A		Category B		Individual PPF	Individual PPF compliance?	
					Criteria	Option 3 complies?	Criteria	Option 3 complies?	dB $L_{Aeq(24h)}$		
A	73	74	76	76	64	N	67	N	–	Not applicable	Y
B	72	73	74	74	64	N	67	N	–	Not applicable	Y
C	68	69	65	65	64	N	67	Y	–	Not applicable	N
D	67	68	64	64	64	Y	67	Y	–	Not applicable	N
E	67	68	64	64	64	Y	67	Y	–	Not applicable	N
F	70	71	67	67	64	N	67	Y	–	Not applicable	N
								Cluster average	Not applicable		
								Cluster compliance	Not applicable		

A5.7 Comparison of mitigation options

Using the information from tables B43, B45, and B47 compare the relative effectiveness and merits of each mitigation option with a view to determining the best practicable option. The three mitigation options are described in table A48 and are compared in table A49.

Table A48 – Example 4 – Mitigation option details

Option number	Detail	Notes
1	Barrier	2 m (high) by 80 m (long) noise barrier as shown in figure A19. Noise barrier for PPFs A and B has a gap to provide vehicle access to dwellings from altered road
2	Barrier and insulation	2 m (high) by 80 m (long) noise barrier as shown in figure A20 for PPF F and acoustic insulation for PPFs A and B
3	Insulation	Acoustic insulation for PPFs A and B

Table A49 – Example 4 – Comparison of mitigation options

Detail	Mitigation option 1	Mitigation option 2	Mitigation option 3
Structural mitigation	Noise barrier		
	2 m (high) by 80 m (long)	2 m (high) by 80 m (long)	Not applicable
	Low-noise road surface		
	Not applicable	Not applicable	Not applicable
Road surface material	SMA	SMA	SMA
Building modification mitigation	Number of PPFs = 0	Number of PPFs = 2	Number of PPFs = 2
Altered road noise criteria compliance	Category A = 50% (3 of 6)	Category A = 50% (3 of 6)	Category A = 33% (2 of 6)
	Category B = 100% (6 of 6)	Category B = 67% (4 of 4)	Category B = 67% (2 of 6)
	Category C = Not applicable	Category C = Not applicable	Category C = Not applicable
Structural mitigation performance compliance	Not applicable	Clusters = 0% (0 of 1)	Clusters = 100% (1 of 1)
	Individual PPFs = 67% (2 of 3)	Individual PPFs = 0% (0 of 1)	Not applicable
Rank by preference	1	2	3

CA5.7 *A benefit-cost analysis could also be undertaken of each noise mitigation option using the methodology provided in Appendix D. This would provide additional information to assist the decision-making process for identifying the best practicable option.*

A5.8 Discussion

From a noise management perspective mitigation option 1 is preferred to the other two options. Although option 1 delivers the same degree of compliance with the Category A noise criteria for altered roads as option 2, the noise barriers proposed in option 1 achieve 100% compliance with the relevant Category B criterion. As a result, option 1 avoids the need for building modification mitigation such as acoustic insulation. By contrast since options 2 and 3 do not meet the Category B criterion at two dwellings and the internal noise level is predicted to be above 45 dB $L_{Aeq(24h)}$, acoustic insulation would need to be applied to these PPFs.

The development of mitigation options is an iterative process. Therefore it is essential that there is early and ongoing dialogue between the acoustician(s) responsible for the noise assessment and specialists from other disciplines, such as traffic engineers, urban designers, planners, property managers, archaeologists, and quantity surveyors. These specialists might raise issues such as safety, visual appearance, cost, or effects on historic places that also need to be taken into account. As a result, mitigation option 2, mitigation option 3, or a modified version of mitigation option 1 might represent the best practicable option, for example if the current mitigation option 1 gives rise to unacceptable safety risks associated with the access provisions provided by the noise barrier proposed for PPFs A and B.

APPENDIX B – APPROACHES TO NOISE MANAGEMENT

(Informative)

B1 INTRODUCTION

This appendix contains tables B1 and B2 which detail approaches to traffic-noise management, both through mitigation options and planning processes. The content of these tables is summarised in B1.1 and B1.2.

B1.1 Mitigation options

The following summarises the mitigation options discussed in table B1.

Vehicle noise emission regulations – The Ministry of Transport develops policy and regulations for sound emitted from vehicles. These regulations are administered by the New Zealand Transport Agency (NZTA).

Traffic management – Speed limits or traffic-calming measures can be used to reduce vehicle speeds, and travel demand management can be used to reduce vehicle numbers. Reducing vehicle speed or numbers can reduce traffic noise levels, although significant changes are needed to have an appreciable impact.

Low-noise road surfaces – Different road surfaces have different noise characteristics associated with tyre-road interaction. Low-noise surfaces have been used for many years and their development is continuing.

Road alignment – Removal or attenuation of traffic noise can be effectively achieved in the early stages of design by modifying route selection, horizontal/vertical alignment, and gradient. However, these options can be expensive and are generally only available for new roads.

Driver education/behaviour – In many situations, noise disturbance is caused by peak noise events, which are often related to driver behaviour and individual vehicle noise. Creation of quiet zones, signage, and traffic calming can assist noise reduction.

Noise propagation – The specific and changing environment that a road passes through impacts on the propagation path of noise. Noise reduces with distance from a road, and soft ground and natural barriers such as hills can reduce noise.

Noise barriers and bunds – Barriers and bunds work by interrupting the acoustic line-of-sight / transmission of noise along a propagation path between the source and receiver. Barriers and bunds generally need specific design to provide the required noise reduction and can have other effects such as safety and visual impacts.

Building design and layout, building relocation – Effects of traffic noise can be managed within a site using a number of site-specific approaches. These include the design and layout of buildings on the site, or possibly the relocation of existing buildings.

Voice amplification – In sensitive environments such as school classrooms, traffic noise can be managed to some extent by using a voice amplification system to increase the sound level of the teachers' voices.

Acoustic insulation – Indoor noise levels in noise-sensitive buildings can be reduced by modifying the design of new buildings and altering existing buildings to enhance the acoustic insulation provided by the building envelope. However, noise in outdoor areas is not altered, and there are ventilation considerations.

B1.2 Planning process

The following summarises the planning process discussed in table B2.

Land-use planning and reverse sensitivity – Road-traffic noise effects can be effectively addressed through land-use planning to minimise the exposure of noise-sensitive receivers to noise. This is usually achieved through district plan zoning, and district plan and regional coastal plan rules.

Designation and resource consent processes – Road controlling authorities and developers are bound by the Resource Management Act when altering existing roads or constructing new roads. The Resource Management Act sets out processes for designations and resource consents which enable conditions to be imposed to control environmental effects and facilitate construction, maintenance, and operation of infrastructure such as roads.

Urban design – Urban design seeks to ensure that the design of buildings, places, spaces, and networks make a significant difference to the quality of our towns and cities. Integration of different modes of transport addresses traffic congestion and the resulting noise.

Table B1 – Approaches to noise management – Mitigation options

Approach	Description	Further reading
Vehicle noise emission regulations	Sound emitted from an individual vehicle is normally a transient event and can be assessed against LAFmax A-limits. However, sound levels emitted by the combination of vehicles in traffic flows are assessed using $L_{Aeq(24h)}$ as the metric. The Ministry of Transport administers a suite of regulations that seeks to control sound emitted from an individual vehicle. Controls on noisy vehicles are under two separate Land Transport Rules. These are the Land Transport Rule: Vehicle Equipment (previously Regulation 81 of the Traffic Regulations) and the Land Transport (Road User) Rule. In general the Vehicle Equipment Rule sets out controls for vehicles entering the fleet and in service, and the Road User Rule sets out controls on how vehicles are operated. The 2007 amendments to the Vehicle Equipment Rule came into force on 1 June 2008. The amendments tighten the subjective noise test procedure for vehicles with modified exhaust systems at Warrant or Certificate of Fitness (WoF of CoF) inspections. If the vehicle fails a warrant or certificate of fitness for excessive noise the owner has the option to repair the exhaust or to pay for a metered objective test. In addition to the 2007 amendment to the rule, a series of further amendments has been proposed to tackle noisy exhausts. Proposed amendments include the reduction of the decibel limit for new and used vehicles entering the fleet. These proposals have been consulted on as part of the normal rule making process and are expected to be finalised during 2010. The Land Transport Act and the Sentencing Act were amended to adjust enforcement powers and vehicle confiscation powers respectively. The amendments to these Acts came into effect on 1 December 2009 and are targeted at those using vehicles in illegal street races that are dangerous, disruptive, and an antisocial use of vehicles. These two Acts are designed to address noise associated with illegal street races by penalising the drivers by targeting their licence and their vehicle. The 2009 Act amends the previous $150 penalty (which carried no demerit points) for operating a vehicle with a noisy exhaust to a $50 infringement which carries 25 demerit points. This change is intended to demonstrate the seriousness of the offence and means that it will take much less time to reach the 100 demerit-point threshold at which time a driver's licence will be suspended. Other measures include the amendment to legislation governing vehicles that breach the Vehicle Equipment Rule for noise. Previously, Police could order a vehicle off the road if it was believed to have an exhaust system that did not comply with WoF requirements. The amended Land Transport Act states that a vehicle ordered off the road for excessive exhaust noise must undergo an objective (metered) noise test before obtaining a new WoF. Vehicles that pass the test will have their exhaust systems indelibly marked so the police can identify them as 'legal'.	*Land Transport (Enforcement Powers) Amendment Act 2009*. Retrieved from http://www.transport.govt.nz/legislation/acts/enforcementpowersact/ (1 March 2010) *Land Transport (Road User) Rule 2004*. Retrieved from http://www.legislation.govt.nz/regulation/public/2004/0427/latest/DLM302188.html (1 March 2010) *Land Transport Rule: Vehicle equipment Amendment 2007*. Retrieved from http://www.nzta.govt.nz/resources/rules/ vehicle-equipment-amendment-2007.html (1 March 2010) *Sentencing (Vehicle Confiscation) Amendment Act. 2009*. Retrieved from http://www.legislation.govt.nz/act/public/2009/0037/latest/DLM2095708.html (1 March 2010)

Table B1 – Approaches to noise management – Mitigation options (continued)

Approach	Description	Further reading
Traffic management	Vehicle speed is a key factor affecting the level of noise generated from a given road. In general terms, as vehicle speed increases, so does the level of noise. Although it is theoretically possible to manage noise levels by changing posted speed limits, in New Zealand such changes must be made in accordance with the Land Transport Rule: Setting of Speed Limits and its amendments. The rule is administered by the NZTA and is primarily focused on the safety and efficiency of road networks. In urban environments, traffic-calming measures can be more effective than simply altering speed limits. This is particularly so in residential areas. Typical traffic-calming measures may include road narrowing, traffic islands, pavement changes, and speed humps. Access for large and emergency vehicles needs to be maintained. Travel-demand management is aimed at reducing the total number of vehicles on a transport network, fundamentally by reducing the need to travel, encouraging use of alternative modes such as public transport and encouraging multiple occupancy of vehicles. Reducing the volume of traffic on a particular road will reduce the noise emissions. However, significant volume reductions are required to make a noticeable change to noise emissions.	*Land Transport Rule: Setting of Speed Limits. 2007*. Retrieved from http://www.nzta.govt.nz/resources/rules/setting-of-speed-limits-amendment-2007.html (1 March 2010) *New Zealand Transport Agency. Speed Limits New Zealand*. New Zealand Transport agency: Wellington, 2003. Retrieved from http://www.nzta.govt.nz/resources/speed-limits/speed-limits-nz/docs/speed-limits-nz.pdf (1 March 2010) *Transit New Zealand. Planning policy manual SP/M/001 for integrated planning and development of state highways*. Wellington: Transit New Zealand, 2007. Retrieved from http://www.nzta.govt.nz/resources/planning-policy-manual/ppm.html (1 March 2010)

Table B1 – Approaches to noise management – Mitigation options (continued)

<table>
<tr><th>Approach</th><th>Description</th><th>Further reading</th></tr>
<tr>
<td>Low-noise road surfaces</td>
<td>
<p>Road surface has a significant effect on the level of rolling noise generated as a result of the interaction between vehicle tyres and the road surface. Rolling noise is referred to as 'tyre/road noise'. The level of tyre/road noise generated depends on the mix and the speed of the vehicles. Tyre/road noise dominates other sources of noise for light vehicles at speeds between 30 and 50 km/h and for heavy vehicles at speeds between 40 and 80 km/h.</p>
<p>The design and construction of a road surface affect both the generation and propagation of tyre/road noise. The primary design and construction factors affecting the level of tyre/road noise are the roughness or texture, the texture pattern, and the porosity of the surface structure.</p>
<p>In New Zealand, tyre/road noise levels are measured relative to the performance of 'asphaltic concrete (AC)' type surfaces. The most common low-noise road surface in use is OGPA, which is generally about 2 dB quieter than the AC-type surfaces. By contrast, the noisiest chip seal road surfaces can be up to 6 dB louder than the AC-type surfaces.</p>
<p>The following table provides more detail about the noise performance of different road surfaces used in New Zealand for a 50 km/h speed.</p>
<table>
<tr><th rowspan="3">Vehicle Type</th><th colspan="13">Average noise level (dB)</th></tr>
<tr><th colspan="4">Bituminous mixes</th><th colspan="9">Chipseal over bitumen layer</th></tr>
<tr><th>AC</th><th>Slurry</th><th>OGPA</th><th>Cape seal</th><th>7 mm</th><th>10 mm</th><th>12/7 mm</th><th>12 mm</th><th>16/7 mm</th><th>16/10 mm</th><th>19/12 mm</th><th>16 mm</th><th>19 mm</th></tr>
<tr><td>Light</td><td>68</td><td>69</td><td>69</td><td>68</td><td>71</td><td>71</td><td>74</td><td>72</td><td>75</td><td>74</td><td>74</td><td>73</td><td>75</td></tr>
<tr><td>Heavy</td><td>79</td><td>76</td><td>77</td><td>76</td><td>77</td><td>79</td><td>79</td><td>77</td><td>80</td><td>80</td><td>-</td><td>80</td><td>-</td></tr>
<tr><td colspan="14">AC: asphaltic concrete
Slurry: slurry seal (or micro surfacing)
OGPA: open graded porous asphalt
Cape seal: slurry seal over a chipseal. Results are for type 2 over grade 3 chip.
7 mm: nominal chip sizes, single coat
12/7 mm: nominal chip sizes; two-coat seal</td></tr>
</table>
<p>The noise level of a particular road surface may vary with time. For example, older chip seal surfaces tend to become smoother as they wear, resulting in a slightly lower noise level relative to a newly laid surface despite having the same design standard.</p>
<p>Road surface decisions must also consider safety, longevity, wear, and cost.</p>
</td>
<td>
<p><i>Sandberg, U, and Ejsmont, J A. Tyre/road noise reference book.</i> Sweden: Informex, 2002.</p>
<p><i>Forum of European National Highway Research Laboratories. Guidance manual for the implementation of low-noise road surfaces. Report 2006/02.</i> Belgian: FEHRL, 2006. Retrieved from http://www.trl.co.uk/silvia (1 March 2010)</p>
<p><i>Dravitski, V and Karitch, I. Road surface effects on traffic noise: Stage 3 – Selected bituminous mixes. Land Transport New Zealand research report 326.</i> Wellington: Land Transport New Zealand, 2007.</p>
<p><i>Dravitski, V. Road traffic noise: Determining the influence of New Zealand road surfaces on noise levels and community annoyance. Land Transport New Zealand research report 292. Wellington: Land Transport New Zealand</i> 2006. Retrieved from http://www.nzta.govt.nz/resources/research/reports/292/docs/292.pdf (1 March 2010)</p>
<p><i>Transit New Zealand. New Zealand supplement to the 2007 Austroads pavement design guide.</i> Wellington: Transit New Zealand, 2007. Retrieved from http://www.nzta.govt.nz/resources/nz-supplement-2007-austroads-pavement-design/docs/supplement.pdf (1 March 2010)</p>
</td>
</tr>
</table>

Table B1 – Approaches to noise management – Mitigation options (continued)

Approach	Description	Further reading
Road alignment	The alignment of a road is the controlling factor in the location of noise sources. For example, road alignment may affect the degree to which the effects on PPFs can be avoided, remedied or mitigated; the way noise is propagated between the source and receivers; and the nature and level of noise generated. Factors to be considered when determining the route and the alignment of a new or altered road include the availability of land, the nature and purpose of the new or altered road, and the safety and geometric design. When the route for a new road is being considered, noise mitigation measures should be explored at the time the road alignment is selected. This may involve optimising the distance between the road and any PPFs in order to exploit distance attenuation effects or using the topography of the land to shield PPFs from the noise source (see 'noise propagation'). The underlying topography affects not only the need for features such as cuttings and retaining walls but also the gradient of a road. This affects the extent to which drivers of vehicles need to vary traffic speed, change gear, and use their brakes. Each of these factors affect the engine load, which in turn affects the amount of noise generated. By reducing the gradient of a road the amount of noise associated with vehicle acceleration and deceleration as well as exhaust and engine breaking can be reduced. The impact of gradient on truck noise is particularly noticeable. For example, trucks tend to use their engine brakes from around -2% gradient, whereas cars will tend to use their engine brakes on steeper gradients of more than -8%. A 5% reduction in road gradient can reduce noise levels by around 1.5 dB. When making alterations to existing roads, especially in urban areas, those designing roads should consider using the horizontal alignment to maximise any shielding effects offered by existing natural or human created features. The process of determining the geometric design requirements for a new or altered road alignment can also be used to reduce any likely noise effects. This includes using the shielding effects of embankments, cuttings, retaining walls, and solid safety barriers. In addition, the design process includes design speed considerations (see 'traffic management').	Roads and Traffic Authority of New South Wales. *Noise wall design guideline.* Surry Hills New South Wales: Roads and traffic authority New South Wales, 2006. Section 3. Retrieved from http://www.rta.nsw.gov.au/environment/downloads/environmental_noise_management_manual_v1_0.pdf (1 March 2010) Transit New Zealand. *Planning policy manual SP/M/001 for integrated planning and development of state highways*. Wellington: Transit New Zealand, 2007. Retrieved from http://www.nzta.govt.nz/resources/planning-policy-manual/ppm.html (1 March 2010) Transit New Zealand. *State Highway geometric design manual. Section 5: Vertical alignment*. Wellington: Transit New Zealand, 2000. Retrieved from http://www.nzta.govt.nz/resources/state-highway-geometric-design-manual/shgdm.html (1 March 2010) United Kingdom Department of Transport and Welsh Office. *Calculation of road traffic noise* (CoRTN). London: HMSO, 1988.

Table B1 – Approaches to noise management – Mitigation options (continued)

Approach	Description	Further reading
Driver education/ behaviour	Individual driver behaviour is a significant determinant of noise emissions from specific vehicles. Activities such as deliberate modification of vehicle exhaust systems, lack of maintenance, and aggressive acceleration and deceleration can lead to peak noise events that cause annoyance or disturbance (see 'vehicle noise emission regulations'). Driver education can either be general or site specific. General education approaches may involve driver education and training as part of driver licensing and ongoing training. Site specific approaches may involve signage, noisy vehicle enforcement programmes, and traffic calming. Of these, signage is a useful mechanism to reduce some types of vehicle noise, particularly by encouraging the use of alternative routes and less noisy braking systems on some heavy vehicles. Overall, driver education complements other solutions, rather than being a stand-alone solution that gives measurable short-term results.	
Noise propagation	Noise changes both in level and frequency as it travels or propagates from a source to a receiver. There are a number of factors that affect the degree of change including distance, ground absorption, meteorological effects, and the extent of natural or human-made shielding between the source and receiver. Traffic noise acts like a cylindrical 'line' source consisting of a number of point sources. This affects the geometric spreading of the noise and means that noise levels tend to reduce by approximately 3 dB for each doubling of distance between the source and receiver. The amount of ground absorption between a noise source and a receiver affects the amount of reflection. Hard surfaces, such as car parks or water bodies, are relatively reflective and will not normally result in any reduction in noise level. By contrast, soft surfaces such as loose dirt, grassland or bush, can provide an additional reduction of up to 1.5 dB. As a result noise can reduce by up to 4.5 dB for each doubling of distance between a source and receiver when both ground absorption and distance attenuation effects are considered. There are a range of meteorological conditions that can have both positive and negative impacts on the propagation of noise. Such effects are associated with various meteorological parameters including wind, temperature, humidity, and rain. Given the lack of control over such effects, most noise models use neutral meteorological conditions as the basis for prediction. NZS 6801 provides further detail on this subject. The topography and natural terrain between a source and receiver can act as a shield. This reduces noise levels by restricting the direct transmission of noise along a propagation path and by absorbing some of the noise. Man-made features such as buildings, barriers, walls, embankments, and bunds can also provide shielding from noise in the same way as natural features. Depending upon the alignment of a road and the site geometry, the first row of houses or buildings next to a road may offer shielding from noise to second and subsequent rows. 'Noise barriers and bunds' specifically discusses the shielding offered by these features.	NZS 6801:2008 *Acoustics – Measurement of environmental sound.* NZS 6802:2008 *Acoustics – Environmental noise.*

Table B1 – Approaches to noise management – Mitigation options (continued)

Approach	Description	Further reading
Noise barriers and bunds	Solid noise barriers and bunds can be used to shield receivers from sources of noise. Barriers and bunds work by creating an obstacle that breaks the acoustic 'line-of-sight' between the receiver and the source; as a result reducing the transmission of noise along the 'propagation path'. A barrier can in theory reduce noise levels by as much as 15 dB. However, typical performance tends to lie between 5 and 10 dB. The effectiveness of a barrier will depend on its density, height, length, and location. Noise barriers are more cost-effective when they are used for reducing noise received at a group of receivers (cluster) rather than when they are used for reducing the noise received at a single receiver. To ensure adequate 'transmission loss', noise barriers should generally be constructed of materials that have a surface density of at least 10 kg/m² and built with no gaps to allow sound transmission. Suitable materials include concrete, fibre-cement board, steel, and wood. In addition to purpose-designed noise barriers, other roadside features such as solid safety barriers (commonly referred to as 'New Jersey barriers') and earth bunds can also act as noise barriers. Where circumstances permit, New Jersey barriers can address both road safety and noise issues as a single cost-effective solution. In addition to shielding noise, noise bunds can also be used to address aesthetic and landscaping issues. Noise bunds can provide a more visually appealing noise mitigation solution than a purpose-designed noise barrier, and bunds may be able to be created using excess fill from a new road cutting, thus reducing the costs associated with removing and disposing of such material off-site. Although noise barriers can help to mitigate the adverse effects of noise they can also, often because of their significant height, length, and geometry of the face of the walling system, create safety and visual effects of their own. To minimise such effects, it is important that where practicable, noise barriers are designed to take the local environment into account. While the safety and visual impacts of noise barriers and bunds can be addressed through careful design and landscaping, there are a number of other factors that also need to be taken into account. These include traffic and personal safety issues, potential for graffiti, access requirements, expected life of the noise barrier structure, barrier and landscape maintenance as well as shading effects (See 'urban design'). For landscaping vegetation to provide more than minor noise attenuation, a wide strip of densely planted trees should be placed between the noise source and receiver. Typically a 30 m wide strip of suitably dense trees may reduce noise by up to 5 dB where it obstructs the line of sight between the source and receiver.	Benz, K, and English, C. *Environmental noise barriers – A guide to their acoustic and visual design*. New York: Taylor & Francis Group, 2009. Farnham, J, and Beimborn, E. *Noise barrier design guidelines*. Milwaukee: Center for Urban Transportation studies, University of Wisconsin – Milwaukee, 1990. Retrieved from http://www4.uwm.edu/cuts/noise/noisea.htm (1 March 2010) Roads and Traffic Authority of New South Wales. *Noise wall design guideline*. Surry Hills New South Wales: Roads and traffic authority New South Wales, 2006. Section 4. Retrieved from http://www.rta.nsw.gov.au/environment/downloads/environmental_noise_management_manual_v1_0.pdf (1 March 2010)

Table B1 – Approaches to noise management – Mitigation options (continued)

Approach	Description	Further reading
Building design and layout, building relocation	There are a number of site-specific approaches that can be taken to reduce the effects of noise at PPFs. These include the use of acoustic insulation (see the section on 'acoustic insulation' below), the design and layout of buildings, the relocation of existing buildings, and voice amplification systems (see 'voice amplification'). Designing buildings and spaces so that the building itself acts as a noise barrier can be effective, especially in densely populated areas. These techniques have been used successfully where land is of high value. Site-specific noise mitigation measures are best considered as a package of measures. Such measures are better assessed on a case-by-case basis; thus, the site conditions and the nature and structure of the PPFs will be significant controlling factors. In addition any controls in the relevant district or regional coastal plan and New Zealand Building Code requirements need to be considered.	Building Act 2004 and Building Regulations 1992 (Schedule 1 New Zealand Building Code). Retrieved from http://www.legislation.govt.nz/act/public/2004/0072/latest/DLM306036.html (1 March 2010) Consumerbuild. *Moving a house*. nd. Retrieved from http://www.consumerbuild.org.nz (1 March 2010) Hong Kong Environment Protection Department. *Environmental noise – Mitigation measures*. nd. Retrieved from http://www.epd.gov.hk/epd/noise_education/web/ENG_EPD_HTML/m4/mitigation_2.html (1 March 2010)
Voice amplification	In noise-sensitive internal environments where speech communication is a primary function, low-level amplification of voices can enhance communication without being intrusive, such as the use of teacher voice-amplification systems in educational premises. However, these systems do not address other important interactions in educational premises such as students communicating with a teacher or each other.	Ministry of Education. *Designing quality learning spaces – Acoustics*. Wellington: Ministry of Education, 2007. Retrieved from http://www.minedu.govt.nz/~/media/MinEdu/Files/EducationSectors/PrimarySecondary/SchoolOpsPropertyManagement/Guidelines/AcousticsGuide.pdf (1 March 2010)
Acoustic insulation	The design of a building can help to mitigate the effect of noise by 'insulating' it from exterior noise sources. Various building materials and systems offer different levels of acoustic insulation. Acoustic insulation can be retrofitted to PPFs. However, this is generally more expensive and the available reduction is usually less compared to new buildings with good acoustic design. Acoustic insulation is a limited tool, in that it does not mitigate noise levels in outdoor living areas or outdoor public spaces. In addition, the design of acoustic insulation needs to incorporate adequate ventilation, as actions such as opening a window or door will often void any mitigation provided by acoustic insulation. For new buildings, a range of guidance and Standards is available, including information on a possible change to NZBC Clause G6 as well as AS/NZS 2107. This Standard includes recommended criteria for a variety of rooms and building uses and are mainly intended for new or retrofitted buildings in an existing noisy environment.	AS/NZS 2107:2000 *Acoustics – Recommended design sound levels and reverberation times for building interiors.* ISO 140-5:1998 *Acoustics – Measurement of sound insulation in buildings and of building elements – Part 5: Field measurements of airborne sound insulation of façade elements and façades.*

Table B2 – Approaches to noise management – Planning process

Approach	Description	Further reading
Land-use planning	Land-use planning most often occurs under the Resource Management Act, which contains specific provisions on noise and infrastructure. These include, but are not limited to: (a) Section 2 (definitions of 'road', 'noise', and 'infrastructure'); (b) Section 16 (Duty to avoid unreasonable noise); (c) Section 30(1)(d) (Functions of regional councils in the coastal marine area); (d) Section 31 (Functions of territorial authorities); (e) Section 166 – 186 (Part 8 – Designations) discussed in 'designation process'; (f) Section 326 (Excessive noise). Land-use planning attempts to address noise in a strategic manner. It can provide consistency and certainty when implemented early in the planning process. Land-use planning approaches to control the effects of noise can occur at a national, regional, or district/city level and can be complemented by other measures such as bylaws (for example, restrictions on engine braking) and urban design (see 'urban design'). Land-use planning options include: (g) National approaches – national policy statements, national environmental standards, the New Zealand Transport Strategy, New Zealand Standards, building codes, and the Urban Design Protocol; (h) Regional approaches – regional policy statements, regional plan objectives, policies, rules, and associated standards; regional land transport strategies and associated transport policies; (i) District/city approaches – district plan objectives, policies, rules, and associated standards, such as rules and standards relating to noise barriers, building design, setbacks, site layout, and building orientation. District/city and regional approaches are most commonly used and specific planning options include: (j) Location policies – such as policies recognising a hierarchy of roads within a district/city, policies encouraging new housing to locate in close proximity to public transport (which assists in reducing the need for travel by private vehicles and, therefore, the magnitude of noise generated); (k) Control-based measures – plan rules specifying suitable building setbacks from major arterial roads. Plan rules restricting the development of certain land uses near existing or planned road corridors, zoning, the use of structure plans to control site layout to reduce the transmission of, or exposure to, noise, or performance standards for noise-sensitive activities (for example, rules/standards requiring specified internal sound levels to be met); (l) Urban design – such as using plan rules and structure plans to achieve mixed use developments that aim to reduce private vehicle use or to control the location, orientation, and design of buildings to reduce noise impacts; (m) Strategic land-use planning – such as promoting land-use patterns that reduce dependence on private vehicles and subsequent road-traffic related noise. As always with land-use planning, it is not appropriate to undertake a planning exercise with a single focus. Accordingly, noise outcomes will always need to be balanced with other national, regional, and local planning objectives. Land-use planning approaches could make reference to this Standard and specify that noise shall be predicted, measured, assessed, and mitigated in accordance with this Standard. Examples of model District Plan provisions can be found on the Quality Planning website.	McCallum-Clark, M, Hardy, R, and Hunt, M. *Transportation and noise – Land use planning options for a quieter New Zealand. Land Transport New Zealand research report 299.* Wellington: Land Transport New Zealand 2006. Retrieved from http://www.nzta.govt.nz/resources/research/reports/299/docs/299.pdf (1 March 2010) Ministry for the Environment. *The New Zealand urban design protocol*, Wellington: Ministry for the Environment, 2005. Ministry of Transport. *The New Zealand Transport Strategy*, Wellington: Ministry of Transport, 2008 Parliamentary Commissioner for the Environment. *Hawke's Bay Expressway – Noise and air quality issues.* Wellington: Parliamentary Commissioner for the Environment, 2005. Retrieved from http://www.pce.govt.nz/work_programme/reports_by_subject/all_reports/land_use/h_bay_expressway (1 March 2010) Quality Planning. *Health and sensitivity effects associated with land transport noise.* nd. Retrieved from http://www.qualityplanning.org.nz/plan-topics/land-transport-noise/health-effects.php (1 March 2010) Quality Planning. *Managing land transport noise under the RMA.* 2006. Retrieved from http://www.qualityplanning.org.nz/plan-topics/land-transport-noise.php (1 March 2010) *Resource Management Act.* 1991. Retrieved from http://www.legislation.govt.nz/act/public/1991/0069/latest/DLM230265.html (1 March 2010) Transit New Zealand. *Planning policy manual SP/M/001 for integrated planning and development of state highways.* Wellington: Transit New Zealand, 2007. Retrieved from http://www.nzta.govt.nz/resources/planning-policy-manual/ppm.html (1 March 2010)

Table B2 – Approaches to noise management – Planning process (continued)

Approach	Description	Further reading
Reverse sensitivity	Reverse sensitivity is the vulnerability of an established activity to objection from a sensitive land use. For example, if a new school is established near an existing road, this may lead to complaints and/or restraints on the upgrading or operation of the road. Land-use planning can address reverse sensitivity noise effects by restricting certain land uses from developing near existing or planned transport corridors. The Parliamentary Commissioner for the Environment's investigation into noise and air pollution from the Hawke's Bay Expressway outlines the reverse sensitivity issue as it relates to land-use planning. The report identifies that reverse sensitivity is difficult to plan for, and is a long-term issue to address, with multiple responsibilities – local authorities, landowners, and those causing the primary effects.	Dormer, A. 'Reverse sensitivity.' *Resource Management Bulletin* (2001): 29 – 32. McGregor, D, Batistich, M, and Harker, J. *'Reverse sensitivity – Growing beyond the boundary'. Resource Management Journal*, (November 2007): 26 – 31. Pardy, B, and Kerr, J. 'Reverse sensitivity – The common law giveth and the RMA taketh away.' *New Zealand Journal of Environmental Law 3* (1999): 93 – 107. Parliamentary Commissioner for the Environment. *Hawke's Bay Expressway – Noise and air quality issues*. Wellington: Parliamentary Commissioner for the Environment, 2005. Retrieved from http://www.pce.govt.nz/work_programme/reports_by_subject/all_reports/land_use/h_bay_expressway (1 March 2010) Transit New Zealand. *Planning policy manual SP/M/001 for integrated planning and development of state highways*. Wellington: Transit New Zealand, 2007. Retrieved from http://www.nzta.govt.nz/resources/planning-policy-manual/ppm.html (1 March 2010)

Table B2 – Approaches to noise management – Planning process (continued)

Approach	Description	Further reading
Designation process	The designation process set out in Part 8 of the Resource Management Act is one of the principal planning mechanisms used to obtain Resource Management Act authorisation for new or altered roads. The designation process allows controls/conditions to be imposed on roading projects to avoid, remedy, or mitigate the effects of noise from those projects. Examples of model consent/designation conditions can be found on the Quality Planning website.	Ministry for the Environment. *An everyday guide to the Resource Management Act Series 4.1: The designation process*. Wellington: Ministry for the Environment, 2009. Retrieved from http://www.mfe.govt.nz/publications/rma/everyday/designations/ (1 March 2010) Ministry for the Environment. *Striking a balance – A practical guide on consultation and communication for project advocates*. Wellington: Ministry for the Environment, 1999. Retrieved from http://www.mfe.govt.nz/publications/rma/project-advocate-guide-sep99.html (1 March 2010) Quality Planning website (refer to http://www.qualityplanning.org.nz) *Resource Management Act*. 1991. Retrieved from http://www.legislation.govt.nz/act/public/1991/0069/latest/DLM230265.html (1 March 2010)

Table B2 – Approaches to noise management – Planning process (continued)

Approach	Description	Further reading
Resource consent process	Resource Management Act authorisation for a roading project could be obtained by a resource consent rather than a designation. In addition, even when a designation has been obtained for a roading project there may still be a need to obtain resource consent from the regional council in order to authorise certain aspects of a roading project, such as the construction of part of a road in the coastal marine area. A new road (that will ultimately vest in a road controlling authority) is often constructed as part of a subdivision or land-use development. The resource consent process requires application to be made to the relevant council (consenting authority), complete with an assessment of the environmental effects (AEE) of the activity and a statement of any consultation undertaken with potentially affected parties. Examples of model consent/designation conditions can be found on the Quality Planning website.	Ministry for the Environment. *A guide to preparing a basic assessment of environment effects*. Wellington: Ministry for the Environment, 2006. Retrieved from http://www.mfe.govt.nz/publications/rma/aee-guide-aug06/ (1 March 2010) Ministry for the Environment. *An everyday guide to the Resource Management Act Series 2.2: Consultation for resource consent applicants*. Wellington: Ministry for the Environment, 2009. Retrieved from http://www.mfe.govt.nz/publications/rma/everyday/consent-consultation/ (1 March 2010) Ministry for the Environment. *Applying for a resource consent*. 2009. Retrieved from http://www.mfe.govt.nz/publications/rma/everyday/consent-apply/ (1 March 2010) Ministry for the Environment. *Effective and enforceable consent conditions*. Wellington: Ministry for the Environment, 2001. Retrieved from http://www.mfe.govt.nz/publications/rma/enforceable-consents-jun01/ (1 March 2010) Quality Planning website (refer to http://www.qualityplanning.org.nz)

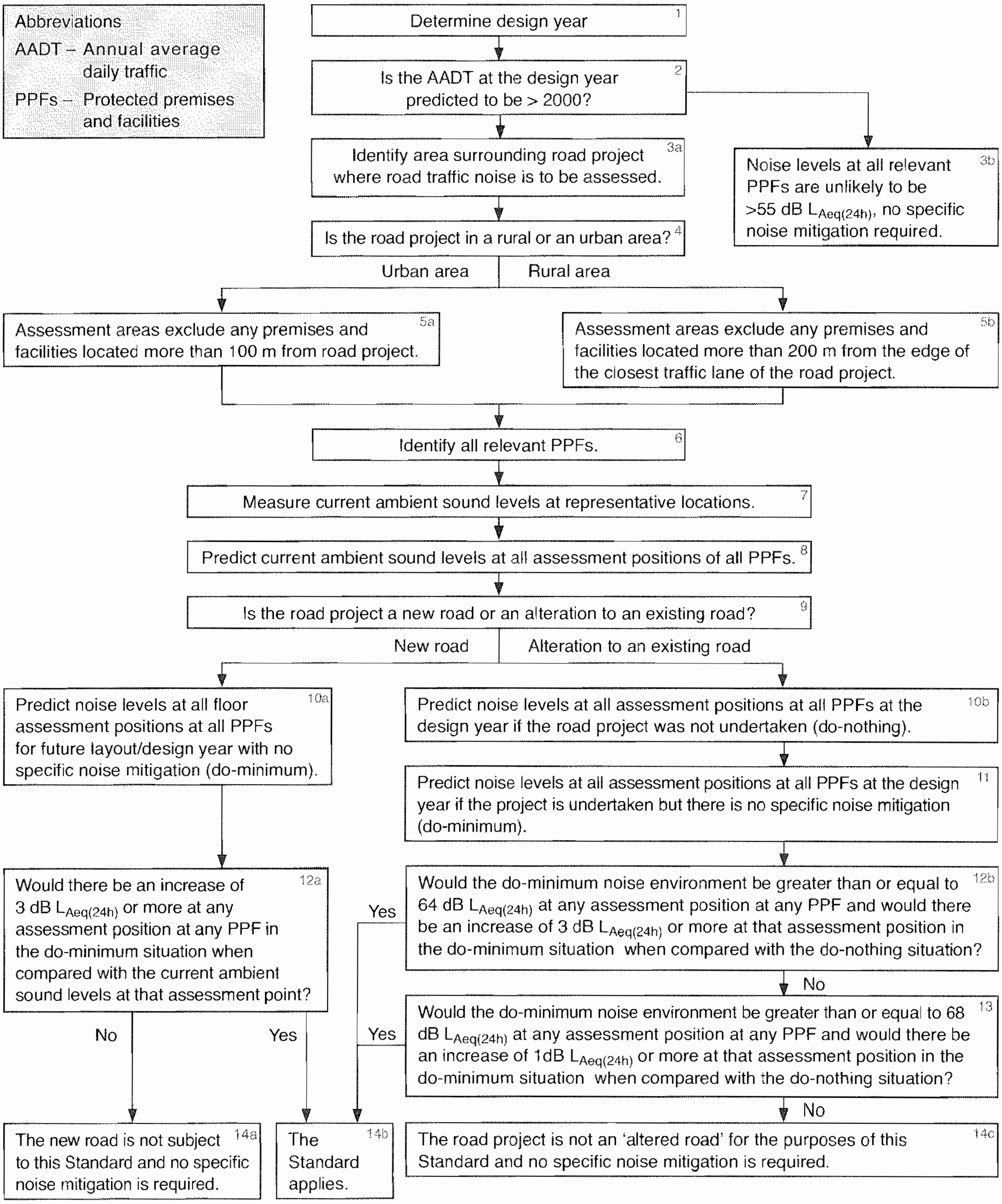
Table B2 – Approaches to noise management – Planning process (continued)

Approach	Description	Further reading
Urban design	Urban design is concerned with the design of the buildings, places, spaces, and networks that make up our towns and cities, and the ways people use them. It ranges in scale from a metropolitan region, city, or town down to a street, public space, or even a single building. Urban design is concerned not just with appearances and built form but with the environmental, economic, social, and cultural consequences of design. Quality urban design produces benefits at a city-wide level as well as at the scale of neighbourhoods and individual buildings or spaces. For example, integrated transport network design and land-use layouts contribute to a better quality of life (such as reduced noise) and encourage healthier lifestyles (with less noise disturbance). The New Zealand urban design protocol is a voluntary commitment to specific urban design initiatives by signatory organisations, which include central and local government, the property sector, design professionals, professional institutes, and other groups. It is the aim of the protocol that, through implementing quality urban design, our towns and cities can become: (a) Competitive places that thrive economically and facilitate creativity and innovation; (b) Liveable places that provide a choice of housing, work, and lifestyle options; (c) A healthy environment that sustains people and nature; (d) Inclusive places that offer opportunities for all citizens; (e) Distinctive places that have a strong identity and sense of place; (f) Well-governed places that have a shared vision and sense of direction.	McCallum-Clark, M, Hardy, R, and Hunt, M. *Transportation and noise – Land use planning options for a quieter New Zealand. Land Transport New Zealand research report 299.* Wellington: Land Transport New Zealand 2006. Retrieved from http://www.nzta.govt.nz/resources/research/reports/299/docs/299.pdf (1 March 2010) Ministry for the Environment. *The New Zealand urban design protocol.* 2005. Retrieved from http://www.mfe.govt.nz/publications/urban/design-protocol-mar05/index.html (1 March 2010) Transit New Zealand. *Planning policy manual SP/M/001 for integrated planning and development of state highways.* Wellington: Transit New Zealand, 2007. Retrieved from http://www.nzta.govt.nz/resources/planning-policy-manual/ppm.html (1 March 2010)

APPENDIX C – DIAGRAMMATIC REPRESENTATION OF APPLYING NZS 6806

(Informative)

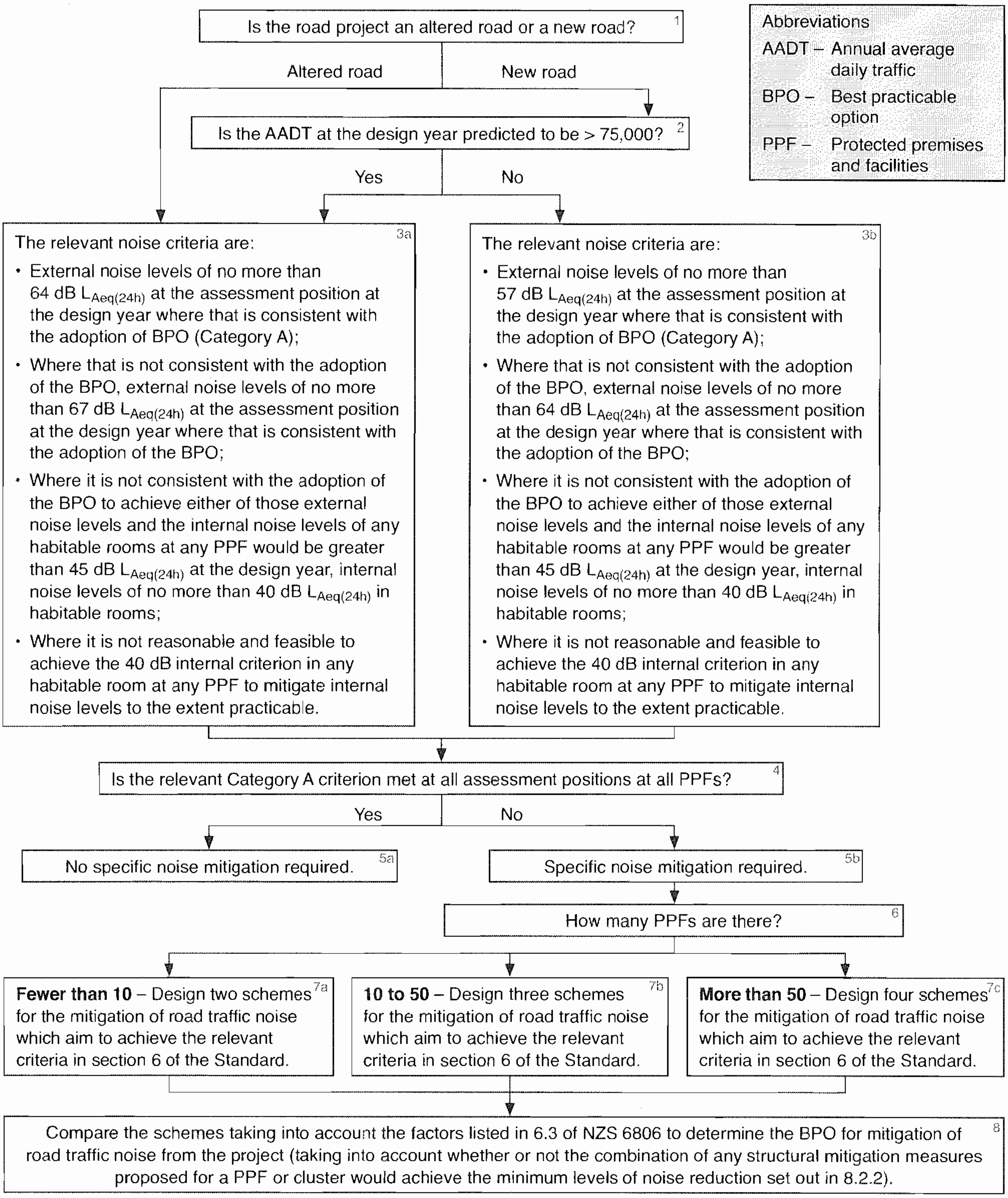
The key elements of the process shown in figure C1 have been integrated into an automated web-based screening procedure available at http://www.acoustics.nzta.govt.nz. The procedure is designed for use by non-noise specialists and is intended to ensure that roading projects which fall outside the scope of this Standard are not subject to unnecessary noise assessments.


Abbreviations
AADT – Annual average daily traffic
PPFs – Protected premises and facilities
Determine design year 1
Is the AADT at the design year predicted to be > 2000? 2
Identify area surrounding road project where road traffic noise is to be assessed. 3a
Noise levels at all relevant PPFs are unlikely to be >55 dB $L_{Aeq(24h)}$, no specific noise mitigation required. 3b
Is the road project in a rural or an urban area? 4
Urban area
Rural area
Assessment areas exclude any premises and facilities located more than 100 m from road project. 5a
Assessment areas exclude any premises and facilities located more than 200 m from the edge of the closest traffic lane of the road project. 5b
Identify all relevant PPFs. 6
Measure current ambient sound levels at representative locations. 7
Predict current ambient sound levels at all assessment positions of all PPFs. 8
Is the road project a new road or an alteration to an existing road? 9
New road
Alteration to an existing road
Predict noise levels at all floor assessment positions at all PPFs for future layout/design year with no specific noise mitigation (do-minimum). 10a
Predict noise levels at all assessment positions at all PPFs at the design year if the road project was not undertaken (do-nothing). 10b
Predict noise levels at all assessment positions at all PPFs at the design year if the project is undertaken but there is no specific noise mitigation (do-minimum). 11
Would there be an increase of 3 dB $L_{Aeq(24h)}$ or more at any assessment position at any PPF in the do-minimum situation when compared with the current ambient sound levels at that assessment point? 12a
Would the do-minimum noise environment be greater than or equal to 64 dB $L_{Aeq(24h)}$ at any assessment position at any PPF and would there be an increase of 3 dB $L_{Aeq(24h)}$ or more at that assessment position in the do-minimum situation when compared with the do-nothing situation? 12b
Yes
No
Would the do-minimum noise environment be greater than or equal to 68 dB $L_{Aeq(24h)}$ at any assessment position at any PPF and would there be an increase of 1dB $L_{Aeq(24h)}$ or more at that assessment position in the do-minimum situation when compared with the do-nothing situation? 13
No
Yes
Yes
No
The new road is not subject to this Standard and no specific noise mitigation is required. 14a
The Standard applies. 14b
The road project is not an 'altered road' for the purposes of this Standard and no specific noise mitigation is required. 14c

NOTE – The identifier in the top right of each box is for reference purposes.

Figure C1 – Determining if NZS 6806 applies

Figure C2 shows the process for determining the noise criteria and mitigating measures.



Is the road project an altered road or a new road?

Is the AADT at the design year predicted to be > 75,000?

Abbreviations

AADT – Annual average daily traffic

BPO – Best practicable option

PPF – Protected premises and facilities

The relevant noise criteria are:

- External noise levels of no more than 64 dB $L_{Aeq(24h)}$ at the assessment position at the design year where that is consistent with the adoption of BPO (Category A);
- Where that is not consistent with the adoption of the BPO, external noise levels of no more than 67 dB $L_{Aeq(24h)}$ at the assessment position at the design year where that is consistent with the adoption of the BPO;
- Where it is not consistent with the adoption of the BPO to achieve either of those external noise levels and the internal noise levels of any habitable rooms at any PPF would be greater than 45 dB $L_{Aeq(24h)}$ at the design year, internal noise levels of no more than 40 dB $L_{Aeq(24h)}$ in habitable rooms;
- Where it is not reasonable and feasible to achieve the 40 dB internal criterion in any habitable room at any PPF to mitigate internal noise levels to the extent practicable.

The relevant noise criteria are:

- External noise levels of no more than 57 dB $L_{Aeq(24h)}$ at the assessment position at the design year where that is consistent with the adoption of BPO (Category A);
- Where that is not consistent with the adoption of the BPO, external noise levels of no more than 64 dB $L_{Aeq(24h)}$ at the assessment position at the design year where that is consistent with the adoption of the BPO;
- Where it is not consistent with the adoption of the BPO to achieve either of those external noise levels and the internal noise levels of any habitable rooms at any PPF would be greater than 45 dB $L_{Aeq(24h)}$ at the design year, internal noise levels of no more than 40 dB $L_{Aeq(24h)}$ in habitable rooms;
- Where it is not reasonable and feasible to achieve the 40 dB internal criterion in any habitable room at any PPF to mitigate internal noise levels to the extent practicable.

Is the relevant Category A criterion met at all assessment positions at all PPFs?

No specific noise mitigation required.

Specific noise mitigation required.

How many PPFs are there?

Fewer than 10 – Design two schemes for the mitigation of road traffic noise which aim to achieve the relevant criteria in section 6 of the Standard.

10 to 50 – Design three schemes for the mitigation of road traffic noise which aim to achieve the relevant criteria in section 6 of the Standard.

More than 50 – Design four schemes for the mitigation of road traffic noise which aim to achieve the relevant criteria in section 6 of the Standard.

Compare the schemes taking into account the factors listed in 6.3 of NZS 6806 to determine the BPO for mitigation of road traffic noise from the project (taking into account whether or not the combination of any structural mitigation measures proposed for a PPF or cluster would achieve the minimum levels of noise reduction set out in 8.2.2).

NOTE – The identifier in the top right of each box is for reference purposes.

Figure C2 – Determining noise criteria and mitigation measures

APPENDIX D – NOISE-MITIGATION BENEFIT-COST ANALYSIS

(Informative)

D1 OVERVIEW

This appendix provides a method of undertaking a noise-mitigation benefit-cost analysis. It is a recognised method supported by international best practice and is based on the valuation of road-traffic noise impacts provided by the New Zealand Transport Agency in section 8 of volume 1 of the *Economic evaluation manual* (EEM).

The approach uses a hedonic pricing methodology and estimates the value of mitigating adverse noise impacts based on the revealed changes in the market value of residential property prices before and after a change in noise levels resulting from the use of a new or altered road.

The methodology provides for noise mitigation benefits throughout the lifetime of each individual PPF affected by a new or altered road. The indicative noise mitigation costs given in table D4 include planning, design, and construction costs but not maintenance costs. If maintenance costs are likely to be incurred these need to be included in the benefit-cost calculation described in D3.

D2 NOISE-MITIGATION BENEFIT

In the EEM the monetised benefit of reducing external noise, per decibel (dB), is valued at 1.2% of the market value of residential properties (dwellings) affected. The EEM approach has been modified to create a nationally consistent benefit-cost analysis method. This approach would allow the entire population of New Zealand to be treated equitably by avoiding geographic differences in residential property values.

This method recommends that the monetised benefit of reducing noise, per dB, should be calculated using the following criteria:

(a) The national median dwelling price should be used to avoid a skewed average price. The latest monthly national median dwelling price available at the time a noise assessment is undertaken in accordance with this Standard should be used. It is recommended that data is sourced from the website of the Real Estate Institute of New Zealand: http://www.reinz.org.nz/reinz/public/market-information/market-information_home.cfm;

(b) The total noise mitigation benefit (x_T) is the sum of the individual subtotal benefits (x_i) calculated for every PPF affected by a new or altered road project. (For the purpose of this calculation any teaching or medical facility, as defined in 1.4.1, should be considered to equate to three PPFs). Benefits should be calculated separately for each noise mitigation option developed for a project;

(c) For each PPF the individual subtotal benefit (x_i) is the sum of the noise mitigation benefit (a_i), additional noise mitigation benefit (b_i) and internal noise mitigation benefit (c_i):

  (i) Noise mitigation benefit (a_i) is the benefit derived from mitigating the external noise effects of a new or altered road relative to the base cases defined in equation 3_{New} (for new roads) and equation $3_{Altered}$ (for altered roads) (see D3)

  (ii) Additional noise mitigation benefit (b_i) is the benefit derived from mitigating the external noise effects of a new or altered road that are additional to the 'existing noise environment: current year: assessment scenario for new roads (equation 3_{New})' and 'do-nothing: design year: assessment scenario for altered roads (equation $3_{Altered}$)' (see table 4 for noise assessment scenarios)

  (iii) Internal noise mitigation benefit (c_i) is the benefit derived from mitigating the internal noise effects of a new or altered road in cases where building modification mitigation is necessary;

(d) Noise mitigation benefit (a_i) should be calculated using a monetised benefit, per dB, at 1.2% of the national median house price. This aligns with the value of noise in the EEM;

(e) Additional noise mitigation benefit (b_i) should be calculated using a monetised benefit, per decibel, of 0.6% of the national median house price. This reflects the fact that this is additional mitigation which will deliver an enhancement to the respective base case noise environments defined in equation 3_{New} and equation $3_{Altered}$;

(f) Internal noise mitigation benefit (c_i) should be calculated using a monetised benefit, per decibel, of 0.3% of the national median house price. This reflects the fact that building modification relative to structural mitigation provides only limited benefit, for example external noise levels remain elevated. (Building modification should only be provided in cases where it is not consistent with the adoption of the best practicable option to achieve the external noise levels of Categories A or B in table 2.)

D3 CALCULATION OF NOISE MITIGATION BENEFIT FOR EACH PROTECTED PREMISES OR FACILITY

D3.1 New road

D3.1.1 Subtotal noise mitigation benefit

Equation 3_{New}

In this version of equation 3, x_i, a_i, b_i and c_i are written as x_{New}, a_{New}, b_{New}, and c_{New} respectively.

$$\begin{array}{l}\text{Subtotal noise}\\ \text{mitigation benefit}\\ \\ (x_{New})\end{array} = \begin{array}{l}\text{Noise mitigation}\\ \text{benefit}\\ \\ (a_{New})\end{array} + \begin{array}{l}\text{Additional}\\ \text{mitigation}\\ \text{benefit}\\ (b_{New})\end{array} + \begin{array}{l}\text{Internal noise}\\ \text{mitigation}\\ \text{benefit}\\ (c_{New})\end{array}$$

If the mitigated noise level is equal to or greater than the existing noise level, then D3.1.2 applies. If the noise level is less than the existing noise level, then D3.1.3 applies.

D3.1.2 Mitigated noise level is equal to or greater than existing noise level

The noise mitigation benefit is calculated as follows:

$$\begin{array}{l}\text{Noise mitigation}\\ \text{benefit } (a_{New})\\ \\ \end{array} = \left(\begin{array}{l}\text{Do-minimum:}\\ \text{Design year:}\\ \text{Noise level}\end{array} - \begin{array}{l}\text{Mitigation option}\\ \text{\#: Design year:}\\ \text{Noise level}\end{array}\right) \text{ x } \begin{array}{l}\text{1.2\% of}\\ \text{National median}\\ \text{house price}\end{array}$$

Additional noise mitigation benefit (b_{New}) = 0

Internal noise mitigation benefit (c_{New}) is calculated as shown in D3.1.4.

D3.1.3 Mitigated noise level is less than existing noise level

The noise mitigation benefit is calculated as follows:

$$\begin{array}{l}\text{Noise mitigation}\\ \text{benefit } (a_{\text{New}})\end{array} = \left(\begin{array}{l}\text{Do-minimum:}\\ \text{Design year:}\\ \text{Noise level}\\ \end{array} - \begin{array}{l}\text{Existing noise}\\ \text{environment:}\\ \text{Current year:}\\ \text{Noise level}\end{array}\right) \times \begin{array}{l}\text{1.2\% of}\\ \text{National median}\\ \text{house price}\end{array}$$

$$\begin{array}{l}\text{Additional noise}\\ \text{mitigation benefit}\\ (b_{\text{New}})\end{array} = \left(\begin{array}{l}\text{Existing noise}\\ \text{environment:}\\ \text{Current year:}\\ \text{Noise level}\end{array} - \begin{array}{l}\text{Mitigation option}\\ \text{\#: Design year:}\\ \text{Noise Level}\\ \end{array}\right) \times \begin{array}{l}\text{0.6\% of}\\ \text{National median}\\ \text{house price}\end{array}$$

Internal noise mitigation benefit (c_{New}) is calculated as shown in D3.1.4.

D3.1.4 Internal noise mitigation benefit

In cases where it is necessary to implement building modification mitigation then: Noise mitigation benefit (a_{New}) and Additional noise mitigation benefit (b_{New}) are calculated as shown in D3.1.2 and D3.1.3 on the basis of external noise levels.

If Mitigation option # includes both structural (such as low-noise road surfaces and/or barriers) and building modification mitigation then:

$$\begin{array}{l}\text{Internal noise}\\ \text{mitigation}\\ \text{benefit } (c_{\text{New}})\end{array} = \left(\begin{array}{l}\text{Mitigation option \#}\\ \text{(}\underline{\text{excluding}}\text{ building}\\ \text{modification mitigation):}\\ \text{Design year: }\underline{\text{Internal}}\\ \text{noise level}\end{array} - \begin{array}{l}\text{Internal}\\ \text{noise level}\\ \text{criterion}\\ \\ \end{array}\right) \times \begin{array}{l}\text{0.3\% of}\\ \text{National}\\ \text{median house}\\ \text{price}\end{array}$$

Otherwise if Mitigation option # only includes building modification mitigation then:

$$\begin{array}{l}\text{Internal noise}\\ \text{mitigation}\\ \text{benefit } (c_{\text{New}})\end{array} = \left(\begin{array}{l}\text{Do-minimum: Design}\\ \text{year: Internal noise level}\\ \\ \end{array} - \begin{array}{l}\text{Internal}\\ \text{noise level}\\ \text{criterion}\\ \end{array}\right) \times \begin{array}{l}\text{0.3\% of}\\ \text{National}\\ \text{median house}\\ \text{price}\end{array}$$

Internal noise level criterion is the value given for Category C in table 2, unless this is not reasonable or feasible to achieve (see section 6).

Internal noise levels should be calculated on the basis of the predicted external noise levels and the sound insulation performance of the particular building.

D3.1.5 Example calculations – New road

For this example, the benefit of noise mitigation undertaken on a new road project at dwelling 1 is as follows:

National median house price	=	\$340,000
1.2% National median dwelling price	=	\$4,080
0.6% National median dwelling price	=	\$2,040
0.3% National median dwelling price	=	\$1,020

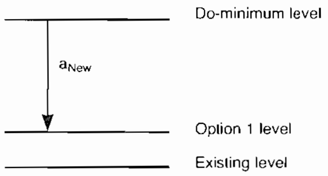
For this example, the national median house price used was calculated at June 2008 (refer to http://www.reinz.org.nz/reinz/public/market-information/market-information_home.cfm).

Table D1 provides the assessment scenarios and noise levels for this example.

Table D1 – Benefit of noise mitigation undertaken on new road project at dwelling 1

Assessment scenario	**Assessment year**	**Noise level** dB $L_{Aeq(24h)}$
Existing noise environment	Current year	55
Do-nothing	Design year	N/A
Do-minimum	Design year	62
Mitigation option 1	Design year	57
Mitigation option 2	Design year	53

Mitigation option 1



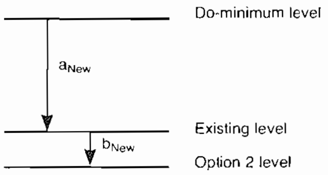
Noise mitigation benefit (a_{New})
= (62 – 57) × \$4,080 = \$20,400

Additional noise mitigation benefit (b_{New})
= \$0

Internal noise mitigation benefit (c_{New}) not applicable

Subtotal noise mitigation benefit (x_{New}) = **\$20,400**

Mitigation option 2



Noise mitigation benefit (a_{New})
= (62 – 55) × \$4,080 = \$28,560

Additional noise mitigation benefit (b_{New})
= (55 – 53) × \$2,040 = \$4,080

Internal noise mitigation benefit (c_{New}) not applicable

Subtotal noise mitigation benefit (x_{New}) = **\$32,640**

Table D2 provides the internal and external noise levels for the assessment scenarios for this example.

Table D2 – Benefit of noise mitigation undertaken on new road project at dwelling 1 with building modification mitigation

Assessment scenario	**Assessment year**	**External noise level** dB $L_{Aeq(24h)}$	**Internal noise level** dB $L_{Aeq(24h)}$
Existing noise	Current year	56	36
Do-nothing	Design year	N/A	N/A
Do-minimum	Design year	72	52
Mitigation option 1 (structural and building modification mitigation	Design year	68	33 (48 – without building modification mitigation)
Mitigation option 2 (only building modification mitigation)	Design year	72	37

Internal noise level criterion = 40 dB $L_{Aeq(24h)}$

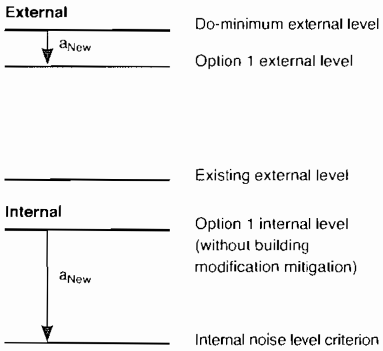
Mitigation option 1

Noise mitigation benefit (a_{New})
= (72 – 68) × $4,080 = $16,320

Additional noise mitigation benefit (b_{New})
= $0

Internal noise mitigation benefit (c_{New})
= (48 - 40) × $1,020 = $8,160

Subtotal noise mitigation benefit (x_{New}) = **$24,480**


External
Do-minimum external level
a_{New}
Option 1 external level
Existing external level
Internal
Option 1 internal level (without building modification mitigation)
a_{New}
Internal noise level criterion

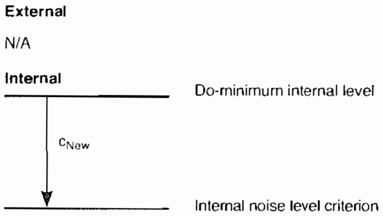
Mitigation option 2

Noise mitigation benefit (a_{New})
= $0

Additional noise mitigation benefit (b_{New})
= $0

Internal noise mitigation benefit (c_{New})
= (52 – 40) × $1,020 = $12,240

Subtotal noise mitigation benefit (x_{New}) = **$12,240**



D3.2 Altered road

D3.2.1 Subtotal noise mitigation benefit

Equation 3_{Altered}

In this version of equation 1, x_i, a_i, b_i and c_i are written as x_{Altered}, a_{Altered}, b_{Altered} and c_{Altered} respectively.

$$\begin{array}{l} \text{Subtotal noise} \\ \text{mitigation benefit} \\ (x_{\text{Altered}}) \end{array} = \begin{array}{l} \text{Noise mitigation} \\ \text{benefit } (a_{\text{Altered}}) \end{array} + \begin{array}{l} \text{Additional} \\ \text{mitigation} \\ \text{benefit } (b_{\text{Altered}}) \end{array} + \begin{array}{l} \text{Internal noise} \\ \text{mitigation} \\ \text{benefit } (c_{\text{Altered}}) \end{array}$$

If the mitigation noise level is equal to or greater than the do-nothing noise level, then D3.2.2 applies. If the noise level is less than the do-nothing noise level, then D3.2.3 applies.

D3.2.2 Mitigated noise level is equal to or greater than do-nothing noise level

The noise mitigation benefit is calculated as follows:

$$\begin{array}{l} \text{Noise mitigation} \\ \text{benefit } (a_{\text{Altered}}) \end{array} = \left(\begin{array}{l} \text{Do-minimum:} \\ \text{Design year:} \\ \text{Noise level} \end{array} - \begin{array}{l} \text{Mitigation option} \\ \text{\#: Design year:} \\ \text{Noise level} \end{array} \right) \text{x} \begin{array}{l} \text{1.2\% of} \\ \text{National median} \\ \text{house price} \end{array}$$

Additional noise mitigation benefit $(b_{\text{Altered}}) = 0$

Internal noise mitigation benefit (c_{Altered}) is calculated as shown in D3.2.4.

D3.2.3 Mitigated noise level is less than the do-nothing noise level

The noise mitigation benefit is calculated as follows:

$$\begin{array}{l} \text{Noise mitigation} \\ \text{benefit } (a_{\text{Altered}}) \end{array} = \left(\begin{array}{l} \text{Do-minimum:} \\ \text{Design year:} \\ \text{Noise level} \end{array} - \begin{array}{l} \text{Do-nothing:} \\ \text{Design year:} \\ \text{Noise level} \end{array} \right) \text{x} \begin{array}{l} \text{1.2\% of} \\ \text{National median} \\ \text{house price} \end{array}$$

$$\begin{array}{l} \text{Additional noise} \\ \text{mitigation benefit} \\ (b_{\text{Altered}}) \end{array} = \left(\begin{array}{l} \text{Do-nothing:} \\ \text{Design year:} \\ \text{Noise level} \end{array} - \begin{array}{l} \text{Mitigation option} \\ \text{\# Design year} \\ \text{noise level} \end{array} \right) \text{x} \begin{array}{l} \text{0.6\% of} \\ \text{National median} \\ \text{house price} \end{array}$$

D3.2.4 Internal noise mitigation benefit

In cases where it is necessary to implement building modification mitigation then: Noise mitigation benefit (a_{Altered}) and Additional noise mitigation benefit (b_{Altered}) are calculated as shown in D3.2.2 and D3.2.3 on the basis of external noise levels.

If Mitigation option # includes both structural (such as low-noise road surfaces and/or barriers) and building modification mitigation then:

$$\text{Internal noise mitigation benefit } (c_{\text{Altered}}) = \left(\begin{array}{l} \text{Mitigation option \#} \\ \text{(excluding building} \\ \text{modification mitigation):} \\ \text{Design year: Internal} \\ \text{noise level} \end{array} - \begin{array}{l} \text{Internal} \\ \text{noise level} \\ \text{criterion} \end{array} \right) \times \begin{array}{l} \text{0.3\% of} \\ \text{National} \\ \text{median house} \\ \text{price} \end{array}$$

Otherwise if Mitigation option # only includes building modification mitigation then:

$$\text{Internal noise mitigation benefit } (c_{\text{Altered}}) = \left(\begin{array}{l} \text{Do-minimum: Design} \\ \text{year: Internal noise level} \end{array} - \begin{array}{l} \text{Internal} \\ \text{noise level} \\ \text{criterion} \end{array} \right) \times \begin{array}{l} \text{0.3\% of} \\ \text{National} \\ \text{median house} \\ \text{price} \end{array}$$

Internal noise level criterion is the value given for Category C in table 2 of this Standard, unless this is not reasonable or feasible to achieve (see section 6).

Internal noise levels should be calculated on the basis of the predicted external noise levels and the sound insulation performance of the particular building.

D3.2.5 Example calculations – Altered road

For this example, the benefit of noise mitigation undertaken on the altered road project at dwelling 2 is as follows:

National median house price = \$340,000
1.2% National median dwelling price = \$4,080
0.6% National median dwelling price = \$2,040

For this example, the national median house price used was calculated at June 2008 (refer to http://www.reinz.org.nz/reinz/public/market-information/market-information_home.cfm)

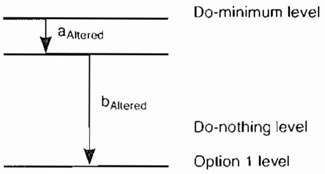
Table D3 provides the assessment scenarios and noise levels for this example.

Table D3 – Benefit of noise mitigation undertaken on altered road project at dwelling 2

Assessment scenario	**Assessment year**	**Noise level** dB $L_{Aeq(24h)}$
Existing noise environment	Current year	66
Do-nothing	Design year	66
Do-minimum	Design year	69
Mitigation option 1	Design year	64
Mitigation option 2	Design year	67

Mitigation option 1

Noise mitigation benefit (a_{Altered})
= (69 – 66) x $4,080 = $12,240



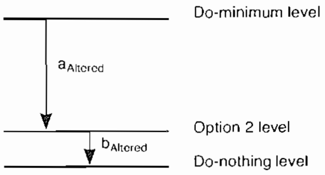
Additional noise mitigation benefit (b_{Altered})
= (66 – 64) x $2,040 = $4,080

Internal noise mitigation benefit (c_{Altered})
not applicable

Subtotal noise mitigation benefit (x_{Altered}) = **$16,320**

Mitigation option 2

Noise mitigation benefit (a_{Altered})
= (69 – 67) x $4,080 = $8,160



Additional noise mitigation benefit (b_{Altered})
= $0

Internal noise mitigation benefit (c_{Altered})
not applicable

Subtotal noise mitigation benefit (x_{Altered}) = **$8,160**

D4 SPECIAL CASES

In certain cases, such as bypasses, a new or altered road may result in traffic being redirected from an existing road that is not subject to any alterations. Where there is a reduction in the annual average daily traffic (AADT) of 50% or more on that existing road (at the design year of the new/altered road relative to the current year), the benefit-cost analysis should also take into account the benefit received by those PPFs affected by noise from the existing road experiencing the reduction in traffic.

D5 NOISE-MITIGATION COST

The total costs of implementing specific noise-mitigation measures for any given project should include all of the costs associated with designing, consenting, constructing, and maintaining the new or altered road, up to and including the design year.

Noise-mitigation costs should only include the costs of measures that would be undertaken solely to reduce noise levels. This includes the costs of both structural and building modification mitigation measures.

The cost of implementing a low-noise road surface as a noise mitigation measure should not be included in the benefit-cost analysis unless such a surface is to be used solely to mitigate noise effects. If this is the case, the cost should be discounted to reflect the differential cost of the surface relative to a standard chip seal surface.

The indicative costs for noise mitigation shown in table D4 may be used for initial noise assessments, such as those forming part of an assessment of environmental effects in support of a new road designation. These costs should be updated to take account of inflation between the base year of the table (2008) and the year that a noise assessment is undertaken using this methodology.

Project-specific noise-mitigation costs should be determined for more advanced noise assessments, for example noise-mitigation plans supporting an outline plan of works.

Table D4 – Indicative noise-mitigation costs (planning, design, and construction) – 2008

Structural mitigation			
Noise mitigation category	**Subcategory**	**Cost/Unit**	**Unit**
Low-noise road surface	OGPA	$25	m^2
	SMA	$30	m^2
	Asphaltic concrete (AC)	$20	m^2
Noise barrier – 1 m	Test level (TL) 4 concrete barrier (810 mm high)	$470	m
	TL 5 concrete barrier (1070 mm high)	$550	m
Noise barrier – 2 m	Timber	$240	m
	Concrete	$350	m
	Acrylic	$1,650	m
Noise barrier – 3 m	Timber	$400	m
	Concrete	$480	m
	Acrylic	$2,500	m
Noise barrier – 4 m	Timber	$450	m
	Concrete	$650	m
	Acrylic	$3,300	m
Noise barrier – 5 m	Timber	$750	m
	Concrete	$1,000	m
	Acrylic	$5,000	m
Noisebund	Non-structural recycled earth	$15	m^3
	Non-structural imported earth	$25	m^3
	Structural recycled earth	$20	m^3
	Structural imported earth	$35	m^3
Building-modification mitigation			
Noise mitigation category	**Subcategory**	**Cost/Unit**	**Unit**
Acoustic insulation	Acoustic double glazing, floor, ceiling and wall cladding/fill/lining, door seals and so on	$15,000	Unit
	Ventilation system only	$10,000	Unit
Education premises	Teacher voice amplification system	$1,000	Room
NOTE – This does not include maintenance costs. If such costs are likely to be incurred with the chosen form of noise mitigation these need to be added to the indicative costs shown.			

D6 NOISE-MITIGATION BENEFIT-COST RATIO

D6.1 Noise-mitigation benefit-cost ratio calculation

The benefit-cost ratio (BCR) should be calculated using equation 2 for each noise-mitigation option developed for a new or altered road project.

Equation 2 benefit-cost ratio calculation

$$\text{Benefit-cost ratio} = \frac{\text{total noise-mitigation benefit}}{\text{total noise-mitigation costs}}$$

The BCR for each noise mitigation option should be compared and ranked.

D6.2 Example calculation of benefit-cost ratio

Road Project A

Mitigation option 1

Total noise mitigation benefit = $380,000
Total noise mitigation cost = $320,000

Benefit-cost ratio = 380,000 / 320,000 = **1.19**

Mitigation option 2

Total noise-mitigation benefit = $365,000
Total noise-mitigation cost = $370,000

Benefit-cost ratio = 365,000 / 370,000 = **0.98**

Mitigation option 3

Total noise-mitigation benefit = $270,000
Total noise-mitigation cost = $180,000

Benefit-cost ratio = 370,000 / 180,000 = **2.05**

Mitigation option 3 has the highest BCR.

NOTE – As stated in section 6 of this Standard the benefit-cost ratio is only one of a number of factors that should be considered in determining whether or not a mitigation option represents the best practicable option.

NOTES

NOTES

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Approved by the Standards Council on 9 April 2010 to be a New Zealand Standard pursuant to the provisions of section 10 of the Standards Act 1988.

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